



Engineering Standards Denver Water


Effective 12/01/2004

Disclaimer and Scope of Applicability

The Engineering Standards set forth herein are prepared for and are applicable **only** in those water service areas served by Denver Water.

 You can download complete [Engineering Standards](#), [Materials Specifications](#), or the [Standard Drawings](#) in PDF format. Each document is between 1-3 Megs.

 If you wish to obtain an Engineering Standard book with CAD details, they are available at Denver Water, 1600 W. 12th Ave., 3rd Floor Engineering, Denver, CO 80204, from [Terri Steele](#) at 303-628-6604. The cost is \$100.00.

 **Attention CAD application users: All CAD files are in AutoCAD 2002 format.**
If a CAD drawing does not open after clicking the link, you can save the drawing locally by right-clicking the link and selecting *Save target as*. All of the CAD drawings on this site use the color/pen width chart here – [Specimen C 4-06C](#) – to conform to Denver Water's standards for plotting.

Section 1 – General

Title	Section
Revision	1-00
Authority	1-01
Effective Date of Standards	1-02
Revisions, Amendments or Additions	1-03
Denver Water Control	1-04
Organization and Interpretation of Standards	1-05
Definitions	1-06
Abbreviations	1-07

Section 2 – Main Extensions

Title	Section
-------	---------

Inside Denver	<u>2-01</u>
Outside Denver	<u>2-02</u>
Extensions Defined	<u>2-03</u>
Engineering Standards to Apply	<u>2-04</u>
Application Procedure	<u>2-05</u>
Construction Procedure	<u>2-06</u>
Plans & Specifications	<u>2-07</u>
Engineering	<u>2-08</u>
Surveying	<u>2-09</u>
Placing Survey Lines	<u>2-10</u>
Inspection	<u>2-11</u>
Contractors	<u>2-12</u>
Points of Delivery	<u>2-13</u>
Special Conditions	<u>2-14</u>
Exceptions Under Chapter 2	<u>2-15</u>

Section 3 – Service Lines & Appurtenances

Title	Section
General	<u>3-01</u>
Ownership & Maintenance	<u>3-02</u>
Layout	<u>3-03</u>
Separate Trenches	<u>3-04</u>
Combination Service Lines	<u>3-05</u>
Pumps	<u>3-06</u>
Tanks	<u>3-07</u>
Connections for Water	<u>3-08</u>
Taps & Saddles	<u>3-09</u>
Size	<u>3-10</u>
Pipe Material	<u>3-11</u>
Curb Stops, Valves & Valve Boxes	<u>3-12</u>
Meters	<u>3-13</u>

Section 4 – Easements & Licenses

Title	Section
General	<u>4-01</u>
Granting an Easement to Denver Water	<u>4-02</u>
Grant an Easement to a Distributor	<u>4-03</u>

Obtaining a License to Use or Cross Denver Water Property	4-04
Acquiring an Easement from Denver Water	4-05
Specimen Sheets Illustrating Procedures	4-06

Specimen Illustration Formats >>

	CAD	PDF
■ <i>General Instructions</i>	G.Ins.	G. Ins.
■ <i>Specimen A. DW Standards</i>	4-06A	4-06A
■ <i>Specimen B. Border/Title Block</i>	4-06B	4-06B
■ <i>Specimen C. Perimeter Description</i>	4-06C	4-06C
■ <i>Specimen D. Overhead Crossing</i>	4-06D	4-06D
■ <i>Specimen E. Underground Crossing</i>	4-06E	4-06E
■ <i>Specimen F. Centerline Description</i>	4-06F	4-06F
■ <i>Specimen G. Simplified Area</i>	4-06G	4-06G
■ <i>Specimen H. Fire Hydrant Easement</i>	4-06H	4-06H

Section 5 – System Design & Layout

Title	Section
General	5-01
Quality of the Distribution System	5-02
Sizing of Distribution Mains	5-03
Fire Protection System	5-04
Operating Pressures within the Distribution System	5-05
Pressure Regulating Stations	5-06
Storage Facilities	5-07
Electric Pump Motors	5-08
Pumping Facilities	5-09
Layout of the Distribution System	5-10
Line Valves	5-11
Connections to Conduits	5-12
Supervisory Control & Data Acquisition (SCADA)	5-13
Interconnects with Other Water Systems	5-14
Flow Measurement	5-15

Section 6 – Materials

Title	Section
Materials & Testing	6-01
Size of Mains	6-02
Pipe Classes	6-03
Selection of Pipe	6-04
Pipe Fittings	6-05
Line Valves	6-06
Pressure Regulating Valves	6-07
Tapping Valves & Sleeves	6-08
Check Valves	6-09
Stop & Waste Valves	6-10
Control Of Backflow & Cross Connection	6-11
Valve Boxes	6-12
Valve Reference Marker Posts	6-13
Meters	6-14
Size Of Meter	6-15
Type Of Meter	6-16
Magnetic Drive Displacement Meters	6-17
Compound & Turbine Meters	6-18
Outside Meter Settings	6-19
Inside Meter Settings & Remote Readers	6-20
Meter Bypass Lines	6-21
Meter Check Valves	6-22
Valves For Use With Meters	6-23
Meter Couplings	6-24
Meter Yokes (Line Setters)	6-25
Valve & Meter Supports	6-26
Meter Pits & Covers for 3/4 Inch and One Inch Meters	6-27
Vaults	6-28
Concrete Structures	6-29
Steel Reinforcement For Concrete	6-30
Manholes	6-31

Manhole Base Slabs & Base Beams	6-32
Sump Pits For Vaults & Manholes	6-33
Vent Pipes	6-34
Manufacturer & Model Of Fire Hydrants	6-35
Fireline Connections To Mains	6-36
Service Lines	6-37
Corporation Stops	6-38
Curb Stops	6-39
Curb Stop Service Boxes	6-40
Corrosion Protection Systems	6-41
Kickblocks	6-42
Protective Concrete Pads Over Pipe	6-43
Casing Pipe	6-44
Miscellaneous Metalwork & Piping	6-45
Air & Vacuum Relief Valves	6-46

Section 7 – Earthwork

Title	Section
Earthwork Defined	7-01
Exploratory Excavation	7-02
Excavation To Line & Grade	7-03
Trenching Operations	7-04
Excavation For Structures	7-05
Surplus Excavation Material	7-06
Blasting	7-07
Dewatering	7-08
Foundations On Unstable Soil	7-09
Pipe Bedding & Pipe Zone Material	7-10
Backfill & Compaction	7-11
Controlled Low Strength Material (CLSM)	7-12
Cleanup	7-13
Surface Restoration	7-14
Subgrade & Road Preparation	7-15

Section 8 – Pipe Installation

Title	Section
Approval By Denver Water	8-01
Handling Of Materials	8-02
Preparation & Inspection Of Pipe & Fittings For Installation	8-03
Pipe Joint Lubricant	8-04
Cutting & Fitting Of Pipe	8-05
Pipe Alignment & Grade	8-06
Deviation From Alignment & Grade Occasioned By Other Structures	8-07
Temporary Bulkheads	8-08
Frost	8-09
Ductile Iron Pipe	8-10
Polyvinyl Chloride Pressure Pipe	8-11
Installation Of Valves	8-12
Installation Of Valve Boxes	8-13
Installation Of Fittings	8-14
Installation Of Tapping Saddles	8-15
Fire Hydrants	8-16
Fireline Connections	8-17
Kickblocks	8-18
Concrete Structures	8-19
Reinforcing Steel For Concrete Structures	8-20
Joint Restraint Devices	8-21
Connections To The Denver Water's System	8-22
Corrosion Protection Systems	8-23
Chlorination	8-24
Hydrostatic Testing	8-25
Acceptance & Release For Taps	8-26
Blow-Off Assembly	8-27
Sewer Crossing	8-28

Section 9 – 16 Inch & 20 Inch Transmission Mains

Title	Section
General	9-01
Other Standards To Apply	9-02
Design Of Transmission Mains	9-03
Plans & Specifications	9-04
Material	9-05
Installation	9-06
Sewer Crossings	9-07
Easement Width Requirements	9-08

Section 10 – 24 Inch & Larger Conduits

Title	Section
General	10-01
Other Standards To Apply	10-02
Preliminary Investigation	10-03
Design	10-04
Plans & Specifications	10-05
Materials	10-06
Installation	10-07
Sewer Crossings	10-08
As-Constructed Drawings	10-09
Easement Width Requirements	10-10

Section 11 – Non-Potable Water System

Title	Section
General	11-01
Other Standards To Apply	11-02
Water Quality	11-03
Potable Water Backup	11-04
Conversion From A Potable To A Recycled Line	11-05
Protection Of The Potable Water System	11-06
Discharges From The System	11-07
User Permits	11-08
Separation From Sewer Lines	11-09

Separation From Potable Water Lines

[11-10](#)

Recycled Water Conduits

[11-11](#)

Recycled Water Transmission Mains

[11-12](#)

Recycled Water Distribution Mains

[11-13](#)

Recycled Water Service Lines & Appurtenances

[11-14](#)

Nonpotable Customers Guidelines

[11-25](#)

Section 12 – Integrated Water System

Title

Section

General

[12-01](#)

Maintenance Programs

[12-02](#)

Distribution System Sampling

[12-03](#)

On-Line Water Quality Monitoring

[12-04](#)

Water Quality Complaints & Communication

[12-05](#)

Facility Operation & Status

[12-06](#)

Reporting Compliance

[12-07](#)

Materials Specifications

Table of Contents

[ToC](#)

Standard Drawings

Table of Contents

[ToC](#)

Revised Eleventh Edition of the Engineering Standards of the Board of Water Commissioners Denver, Colorado

Effective: December 1, 2004

To All Standard Holders:

The enclosed Standards contain the Eleventh Edition of the Engineering Standards of the Board of Water Commissioners, Denver, Colorado, and shall be binding and in full force and effect as of December 1, 2004.

1. The following Twelve Chapters were reprinted in their entirety.
2. The following Materials Specifications were reprinted in their entirety.
3. The Standard Drawings were reprinted in their entirety.

Disclaimer and Scope of Applicability

The Engineering Standards set forth herein are prepared for and are applicable ***only*** in those water service areas served by Denver Water.

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 1 – General

1.01 Authority:

These Standards are promulgated by the Manager of Denver Water pursuant to the authority granted by the Charter of the City and County of Denver, as amended.

The administration of these Standards including interpretation, enforcement, revision, waiver and variance is hereby delegated by the Manager to the Director of Engineering or an appointed representative.

Any variance request must be submitted to the Water Sales Section and forwarded to the Director of Engineering or an appointed representative for review.

1.02 Effective Date Of Standards:

These Standards shall be effective after they have remained posted in a conspicuous public place in the principal business offices of Denver Water for a period of 15 days, and shall supersede all former Engineering Standards of the Board of Water Commissioners, Denver, Colorado.

1.03 Revisions, Amendments Or Additions:

These Standards may be revised, amended, or added to from time to time. Such revisions, amendments and additions shall be binding and of full force and effect when published in the manner set forth in 1.02, above.

1.04 Denver Water Control:

These Standards shall apply to the installation, operation, and maintenance of all water facilities under the control of Denver Water. Such control shall be exercised in accordance with the Charter within Denver and by contract with Distributor Contract areas.

Notwithstanding any variance from these Standards that occurred or was authorized in the past, or that may be authorized in the future, Denver Water shall not be restricted or limited in the exercise of its lawful powers. No action in violation of these Standards, direct or indirect, of or by any person, including any owner, operator, or agent of an owner or operator of any water facility in making any connection, disconnection, repair, or otherwise doing work with respect to any water facility served with water from the Denver Water system, shall continue after discovery of such violation, or the enforcement of corrective action as to such violation.

1.05 Organization And Interpretation Of Standards:

These Standards are composed of written Engineering Standards, Materials Specifications, and Standard Drawings. The interpretation of any section, or of differences between sections, when appropriate, shall be made by the Director of Engineering or an appointed representative, and their interpretation shall be binding and controlling in its application.

Whenever there is a conflict between these Engineering Standards and any referenced standard, specification, or code the most stringent requirement shall apply and shall mean the latest edition.

1.06 Definitions:

As used in these Standards, unless the context shall otherwise require, the words defined in this paragraph shall have the meanings herein ascribed:

A. Applicant for System Extension: Any person, association, corporation, entity, or government agency desiring water service for premises under their control and having been granted a license by Denver Water to receive service; often a subdivider or developer. Also referred to as Applicant.

B. Auxiliary Water Supply: Any water supply on or available to a customer's premises other than Denver Water's approved public water supply.

C. Back-Pressure: Backflow caused by a pump, elevated tank, boiler, pressure in pipe, or any means that could create greater pressure within a piping system than that which exists within the potable water supply.

D. Backflow: The flow of water or other liquids, mixtures, gases, or substances into the distributing pipes of a potable water supply, from any source other than its intended source.

E. Backflow Preventer: A device or method designed to prevent backflow consisting of one of the following:

1. **Air-Gap:** The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device, and the flood level rim of said vessels. An approved air-gap will be at least double the diameter of the supply pipe, measured vertically, above the top of the overflow rim of the overflow rim of the vessel, and in no case less than one inch.
2. **Pressure Vacuum Breaker:** A type of device in which the check valve is designed to close with the aid of a spring when the line pressure drops and at the same time the air relief is designed to open when the internal pressure is just above atmospheric pressure so that no non-potable liquids may be siphoned back into the potable water system. Being spring loaded, it does not rely upon gravity as does the non-pressure type vacuum breaker. This type of device may not be installed where it might be subjected to any back-pressure condition.
3. **Non-Pressure Vacuum Breaker:** A type of device which is better known

as an atmospheric vacuum breaker; and is always placed down stream from the shut-off valve, and, which will cause its vent to close when the water flows in the normal direction. But, as soon as the water ceases to flow, the air vent valve is caused to open, thus interrupting the possible back-siphonage effect. This device should be installed at least 6 inches above the highest outlet and should not be used where it is subject to line pressure for more than 24 hours.

4. Double Check Valve: An assembly of two internally loaded, specially designed and independently operating check valves together with a tightly closing shut-off valve on the upstream and downstream side of the check valves. This type of device is used on all direct or indirect water connections through which pollutants may enter the potable water system under backflow conditions.

5. Reduced Pressure Principle Device: An assembly of two internally loaded, specially designed, and independently operating check valves which also has a mechanically independent, hydraulically dependent relief valve between the check valves, specifically designed to maintain a zone of reduced pressure between the two check valves at all times. This assembly must also have tightly closing upstream and downstream shut-off valves. This assembly is used for the protection of the potable water supply wherever a direct or indirect connection is made to a point of use involving any substance, which might present a health hazard. The only exceptions are in the case of installations where sewage substances are handled under pressure (here no direct connection may be made which might be placed under a back-pressure condition); and, private water supplies (e.g., wells) that may be of lower quality than the public water supply.

F. Backflow Prevention: Prevention of the flow of any foreign liquids, gases, or substances into the distributing pipe lines of a potable supply of water.

G. Backflow Prevention Device: A device accepted and approved by Denver Water as meeting an applicable specification stated or cited in this chapter or as suitable for the proposed use and as approved and accepted by the Colorado Department of Health.

H. Back-Siphonage: A form of backflow due to a negative or sub-atmospheric pressure within a water system.

I. Board: The Board of Water Commissioners or an authorized representative as established by the Charter of the City and County of Denver.

J. Certified Welder: A skilled welder, welding operator or tacker who has had adequate experience in the method of materials to be used and is qualified under the provisions of the American Welding Society Standard (AWS) D1.1 using test position 6G.

Welders shall be qualified by an independent, local, approved testing agency not more than 6 months prior to commencing work. Machine and electrodes similar to

those used in the work shall be used in qualification tests.

K. City and County of Denver: The territorial limits of the City and County of Denver, inside which Denver Water has complete control of the distribution system, including ownership, construction, operation, and maintenance of all facilities, reading of meters, and billing of customers.

L. Conduit: A 24 inch or larger diameter pipe carrying recycled or potable water from or to treatment facilities and storage reservoirs, and to delivery points feeding the distribution system.

M. Consecutive System: A public water system that receives, through purchase or other means, treated water from a supply system and distributes that water, without additional treatment except disinfection, through a distribution system that it owns. A consecutive system may be included in an integrated system.

N. Consumer: Any person, firm, or corporation using or receiving water from the public water system.

O. Contamination: An impairment of the quality of the water by sewage or industrial fluids to a degree which creates a natural hazard to the public health through poisoning or through the spread of disease.

P. Contractor: In the context of these Standards, a Contractor employed by an Applicant for distribution system extension.

Q. Cross Connection Control:

1. **Containment:** Prevention of actual or potential cross connection in the plumbing system of a consumers premises from the public water supply system.
2. **Isolation:** Prevention of actual or potential cross connections within the consumers plumbing system.

R. Denver Water: The plant, facilities, system, assets, and personnel controlled by the Board pursuant to its Charter authority.

S. Distribution Main: See [Water Main](#).

T. Distribution System: Mains of 12 inch and smaller diameter, together with all appurtenant and necessary valves, fire hydrants, taps, meters, service pipes, and associated materials, property, and equipment receiving recycled or potable water from conduits and Transmission mains distributing it to individual consumers.

U. Distributor: Any party to a contract with the Board for the delivery of non-potable or potable water outside the City and County of Denver.

V. Distributor Contract Area: An area which is covered by a contract that furnishes potable or non-potable water to an entity having authority to occupy public streets, roads, and ways as a water utility serving some area outside the City and County of Denver. These areas are classified as "Master Meter" (treated

or untreated water), "Read and Bill" or "Total Service" Areas. Also see [Master Meter Contract Area](#), [Read and Bill Contract Area](#) and [Total Service Contract Area](#).

W. Engineer: The Director of Engineering, who is a member of the Manager's Executive Staff, or an appointed representative.

X. Industrial Piping System: Any system used by a consumer for the transmission or confinement, or storage of any fluid, solid, or gaseous substance other than an approved water supply, including all pipes, conduits, tanks, receptacles, fixtures, equipment and appurtenances used to produce, convey or store substances which are or may be polluted or contaminated.

Y. Inspector: The authorized representative of the Engineer assigned to a jobsite.

Z. Integrated System: Two or more public water systems, one of which is a supply system, whose distribution systems are physically connected and are being operated using a common set of standards for the purposes of maintaining and protecting drinking water quality.

AA. Main Extensions: Extensions to the distribution system that are within the City and County of Denver or Total Service Areas.

BB. Manager: The chief executive officer of Denver Water, designated as such by the Board.

CC. Master Meter Contract Area: An area, in which, by contract, the Distributor is responsible for construction, operation, and maintenance of the system to distribute water to the consumer and for reading the meters of the individual customers and for billing them accordingly.

DD. Non-Toxic Substance: Any substance of a non-poisonous nature that may create a minor or moderate hazard to the domestic water system.

EE. Pollution: An impairment of the quality of the water to a degree which does not create an actual hazard to the public health, but which does adversely and unreasonably affect such waters for domestic use.

FF. Private Pipe Extensions: Extensions to distribution systems that are within Distributor Contract Areas and outside the territorial boundaries of the City and County of Denver.

GG. Read and Bill Contract Area: An area, in which, by contract, the Distributor is responsible for the operation and maintenance of the system to distribute water to the individual customer. Denver Water reads the meter of each customer and bills according to a specified rate.

HH. Section and Division: The words Section and Division are used as organizational subdivisions of Denver Water (e.g. Water Sales Section, Engineering Division, etc.).

II. Service Line: All pipe, fittings, and appurtenances of the licensee for conveying water from Distribution Mains to the consumer.

JJ. Stub-in: A Tap made for the purpose of installing Service Lines prior to the paving of streets. Such connection shall include fittings necessary to extend the Service Line to the valve at the property line.

KK. Tap: Physical connection to a Distribution Main which, together with appropriate license, effects water service to individual consumers.

LL. Total Service Area: An area, in which, by contract, Denver Water is responsible for the operation and maintenance of the system to distribute water to the individual consumer and for reading the individual consumer's meters and for billing them accordingly.

MM. Toxic Substance: Any substance (liquid, solid, or gaseous) including raw sewage and lethal substances which, when introduced into the water supply system, creates or may create a danger to the health and well-being of the consumer.

NN. Transmission Main: A 16 inch or 20 inch diameter pipe receiving recycled or potable water from a conduit and distributing it to individual consumers.

OO. Water Main or Distribution Main: A 12 inch or smaller diameter pipe along public streets or appropriate rights-of-way used for distributing water to individual consumers.

PP. Water – Potable: Water from any source which has been investigated by the health agency having jurisdiction, and which has been approved for human consumption.

QQ. Water – Nonpotable: Water such as treated domestic wastewater, groundwater and well water which is suitable for various beneficial uses excluding human consumption.

RR. Water Purveyor: The owner or operator of the public water system supplying an approved water supply to the public.

SS. Water Supply – Auxiliary: Any water source or system other than the public water supply that may be available in the customer's building or premise.

TT. Water Supply – Unapproved: A water supply, which has not been approved for human consumption by the official health authority having jurisdiction.

UU. Water System – Consumer: Any water system located on the consumer's premises whether supplied by a public potable water system or an auxiliary water supply.

VV. Water Service Connections: The terminal end of a service connection from Denver Water's water system; i.e., where Denver Water loses jurisdiction and quality control over the water at its point of delivery to the customer's water

system. The service connection will mean the downstream end of the meter. There should be no unprotected takeoffs from the service line ahead of any meter or a backflow prevention device located at the point of delivery to the customer's water system. Service connection will also include water service connection from a fire hydrant, fireline, and any other temporary or emergency water service connection from Denver Water's potable water system.

WW. Welder: See [Certified Welder](#).

1.07 Abbreviations:

All references to documents or specifications shall be the latest edition or revision thereof.

A. AASHTO: American Association of State Highway and Transportation Officials

B. AC: Asbestos Cement

C. AFBMA: Anti-Friction Bearing Manufacturers Association

D. ANSI: American National Standard Institute, Inc.

E. ASC: Automatic Sprinkler Connection

F. ASTM: American Society of Testing and Materials

G. AWS: American Welding Society

H. AWWA: American Water Works Association

I. CI: Cast Iron

J. DI: Ductile Iron

K. ERT: Encoder-receiver-transmitter

L. ESMT: Easement

M. FL: Flow Line

N. FLG: Flange

O. FMCT: Fireline Meter and Compound Torrent

P. HGL: Hydraulic Grade Line

Q. ID: Inside Diameter

R. IEEE: Institute of Electrical and Electronics Engineers

S. IP: Iron Pipe

T. ISA: Instrument Society of America

U. KVA: Kilo-Volt-Amperes

V. MEE: Machined Each End

W. MH: Manhole

X. MJ: Mechanical Joint

Y. MOA: Machined Over All

Z. MSS: Manufacturer's Standardization Society of Valve and Fittings

AA. NEC: National Electrical Code

BB. NEMA: National Electrical Manufacturers' Association

CC. NFPA: National Fire Protection Association

DD. NPT: National Pipe Thread

EE. NSF: National Sanitation Foundation

FF. OD: Outside Diameter

GG. OSHA: Occupational Safety and Health Administration

HH. PL: Property Line

II. PRV: Pressure Regulating Valve

JJ. PSF: Pounds per Square Foot

KK. PSI: Pounds per Square Inch

LL. PUD/PBG: Planned Unit Development/Planned Building Group

MM. PVC: Polyvinyl Chloride

NN. SAE: Society of Automotive Engineers

OO. UBC: Uniform Building Code

PP. UMC: Uniform Mechanical Code

QQ. UPC: Uniform Plumbing Code

RR. WOG: Water-Oil-Gas

SS. WRA: Water Reducing Agent

TT. WSC: Water Service Contractor

UU. WSP: Working Steam Pressure

VV. WWF: Welded Wire Fabric

Engineering Standards - Chapter 1:
Revised 07-04, Previous Revision 05-02
End

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 2 – Main Extensions

2.01 Inside Denver:

The Board has complete charge and control of its distribution system inside the City and County of Denver under the provisions of C 4.14 of the Charter. The Board owns, operates, and maintains all facilities within Denver.

2.02 Outside Denver:

The Board supplies water to legal entities outside the territorial boundaries of the City and County of Denver through several contractual agreements. In Total Service Contract Areas, the Board operates and maintains all facilities in a manner exactly the same as those facilities within Denver. In Read and Bill Contract Areas, the Board delivers water into the supply or distribution system and reads customers meters and bills them accordingly. In Master Meter Contract Areas, the Board provides only for the delivery of water by Denver Water into the facilities of the Distributor Contract Area.

2.03 Extensions Defined:

System extensions within the City and County of Denver or Total Service Areas are referred to as "main extensions". System extensions in other Distributor Contract Areas are referred to as "private pipe extensions".

2.04 Engineering Standards To Apply:

All contracts for the receipt of water from Denver Water and, hence, the design and operation of all such systems are subject to all rules and regulations of the Board under the provisions of [Section 14.01](#) of the Board's Operating Rules. These Engineering Standards, therefore, apply uniformly to both main extensions and private pipe extensions subject only to contractual and procedural variations.

2.05 Application Procedure:

Denver Water will establish, and may amend from time to time, procedures to be followed by applicants for extensions of mains or private pipe. These procedures will include all requirements for submittals, fees, engineering design, construction, inspection, acceptance, and warranty. The engineering design and construction portions of the extension applications shall include the following considerations:

For Main Extensions Only:

A. An initial submittal by the Applicant to the Water Sales Section, including an overall or master plan showing the area to be developed and any other adjoining proposed developments by the builder, a preliminary plat of the subdivision, lists of all properties to be served and all taps, if known, to be made on the proposed extension.

B. Denver Water returns to the Applicant its requirements for:

1. Points of connection to existing facilities.
2. Sizes of mains to be installed.
3. Locations of mains to be installed.
4. Special features such as control valves, pressure regulating valves, blowoffs, etc.
5. Acceptable main materials.
6. Participation requirements, if any, in existing facilities.
7. Requirements for easements and/or dedicated public right-of-ways.

For Both Main Extensions And Private Pipe Extensions:

C. The Applicant will submit to the Water Sales Section final plans prepared, stamped, and signed by a Professional Engineer licensed by the State of Colorado for review by Denver Water. This submittal will contain all of the items enumerated in the procedures as established by Denver Water including detailed plans and specifications, recorded plat, overall plan, with details on multiple sheets if necessary, fire department requirements for hydrants, and fire flow, easements, rights-of-way, permits, applications, and fees.

D. For Total Service and inside Denver main installations, the Applicant shall complete and sign Denver Water's Main Extension Application form.

E. Main extensions and private pipeline extensions within distributor districts may also require separate application, plan review fees and review in addition to Denver Water requirements. The Applicant is responsible for determining the requirements of the distributor district complying with those requirements concurrent to the application and review by Denver Water.

2.06 Construction Procedure:

Following final approval of the plans, specifications, and materials the Applicant may proceed with construction. In addition to all construction requirements contained in other portions of these Standards, the Applicant and the Applicant's Contractor shall observe the following:

A. Construction shall commence within 6 months of the approval date shown on the plans, or the plans must be resubmitted for review and approval. If construction on the main installation is halted for more than 6 months, plans must be resubmitted for review and approval.

B. The Applicant shall secure and pay for all easements, licenses and permits

required for the system extension and submit any recorded plats necessary to furnish proof of public street dedication.

C. The Applicant shall pay Denver Water's inspection, reproduction and plan review fees.

D. If the construction involves main extensions within Denver or Total Service Areas, the Contractor shall be bonded to and pre-qualified by Denver Water.

E. The extension shall be accurately surveyed and staked in accordance with the approved plans. See [2.09](#) and [2.10](#).

F. Prior to the installation of water mains in dedicated streets and easements, construction must have progressed to at least sub-grade stage. Sub-grade is defined as an elevation of no more than 7 inches below the official street grade.

G. All valve boxes, fire hydrants, and all other related appurtenances shall be adjusted to the final finished grade by the Contractor.

H. All materials needed to complete the work shall be on hand so that the project may proceed without delay.

I. Adequate provisions for notification of customers who may suffer outages shall be developed. Outages shall be kept to a minimum in compliance with [8.23.C](#).

J. For main extensions inside Denver and Total Service Area, the Contractor shall be responsible for scheduling a pre-construction meeting to include at least the Contractor, the Professional Engineer who has designed the main extension, a representative of Denver Water, and the Applicant. The purpose of the meeting shall be to discuss the construction project, scheduling, and to define responsibilities for the personnel involved in the project. The Contractor shall give at least 48 hours notice to Denver Water (303-628-6627) prior to the pre-construction meeting and prior to commencing construction in private pipe systems. A representative from the distributor district must be present at the pre-construction meeting on private pipe extensions.

In case of an emergency after working hours, call Denver Water's West Side Dispatcher, 303-628-6390.

K. For main extensions, Denver Water shall be notified whenever it becomes necessary to open or close a valve on the existing water system. Only the appropriate Denver Water personnel are authorized to operate valves in Denver or in Total Service Areas. See [8.23.B](#). The Distributor will operate valves in Master Meter or Read and Bill Areas.

L. Mains shall not be installed unless they can be extended from an approved permanent water source, which can supply sufficient water for chlorinating, flushing, and hydrostatic testing.

M. Denver Water shall verify payment of all fees, prepare final documents for main installations and authorize the tapping of the main by Denver Water.

N. All service taps up through 2 inch diameter on both main extensions and private pipe extensions shall be made by Denver Water, except if contractually provided otherwise. All large taps or tee connections made on private pipe extensions shall be inspected by Denver Water. Mains will be tapped only after the conditions and tests outlined in [8.27](#) are met, including having been released by the local health authority having jurisdiction. No tapping of dry mains shall be made or allowed, except on PVC pipe.

O. Only one connection is allowed until all testing is completed.

P. For all Distributor Contract Areas, applications for taps must be received and approved by the Distributor and Denver Water before any taps are made on the main.

2.07 Plans And Specifications:

All Plans and specifications submitted shall be in strict compliance with the Engineering Standards contained herein and shall meet any special conditions that may be reasonably required. The submittal shall clearly present only the required information. The design and installation of all facilities shall insure development of an integrated water system. No work shall commence on any facilities until the Plans and specifications are approved in writing by Denver Water. Plans and specifications should not be submitted for work that will not be installed within 6 months of the approval date.

A. Two sets of detailed Plans and specifications for system extensions shall be submitted to Denver Water's Water Sales Section for approval. Prior to Denver Water's review of the water plans, the appropriate review fee must be paid. The copies will contain the plan requirements as stated below:

1. Water main in plan view showing:

- a. Location and dimensions of dedicated streets, easements, and rights-of-way.
- b. Lots to be served.
- c. All existing or proposed curb and gutter.
- d. The proposed alignment of the water main and the location of all proposed water facilities such as valves, fire hydrants, fittings, etc.
- e. The profile shall also be required on this plan for all water mains 16 inches in diameter and larger.
- f. Proposed elevation, upstream and downstream hydraulic gradient line, and pressure on PRVs.
- g. Indicate that Denver Water has the right to verify PRV settings for Master Meter and Read and Bill areas and Denver Water owns all PRVs connected to Denver Water conduits. In Master Meter and Read and Bill areas, Distributors own all PRVs connected to their lines.
- h. Show meter location for all domestic connections.

2. Combined utilities plan view (separate from the water main plan) containing or showing:

- a. Location and dimensions of dedicated streets, easements and rights-of-way.
 - b. Lots to be served.
 - c. All existing or proposed curb and gutter.
 - d. All existing or proposed utilities. Sewer information may be submitted on a separate sheet.
 - e. All existing or proposed obstructions such as vaults, catch basins, traffic islands, etc.
 - f. The proposed alignment of the water mains and the location of all proposed facilities such as valves, fire hydrants, fittings, etc.
 - g. Show meter location for all domestic connections.
3. Typical street cross-sections showing:
- a. Property/easement lines.
 - b. Street, curb and gutter, and existing or proposed utilities complete with dimensions to property lines.
4. Profile of Centerline of the Pipe showing:
- a. Official street grades.
 - b. Existing ground line.
 - c. Any proposed or existing utility crossing the proposed water main.
 - d. Top of pipe profile of proposed 16 inch and larger water mains, and top of pipe profile of 12 inch water mains if requested by Denver Water.
5. Detail sheets showing all relevant information such as: pipe and fitting restraint, hydrant installations, blow-off installations, proposed crossings, etc.
6. Additionally, all plans shall:
- a. Be made from actual field surveys by a Land Surveyor licensed by the State of Colorado, referenced to land corners or other official survey control points and be of sufficient accuracy so that the facilities can be accurately staked for installation and can be readily located after installation for maintenance, tapping, and control.

In Denver and Total service areas, identify all surface features of the water facilities (i.e. valves, hydrants, manholes, meter pits, etc.) in a coordinate system readily equated to NAD83 State Plane Coordinates, in NAD83 State Plane Coordinates, or Denver Water's Metro Grid Coordinate System with survey accuracy standards by GPS or other survey methods and equated to a unique value for each; such values presented in tabular format as part of the drawings, and submitted to Denver Water by acceptable electronic media. If submittal is in system to be converted to NAD83 State Plane Coordinates, detailed and complete instructions for conversion shall accompany plan submittal. Values on valves, manholes, meter pits, etc. shall be given at the radial point of the feature and on the center of the operating nut of hydrants.
 - b. Show the approved permanent water source, which can supply

sufficient water for chlorination, flushing, and hydrostatic testing and the anticipated water demand for this purpose.

c. Show sufficient adjacent area to give the relation of new facilities to existing facilities.

d. At the time of submittal and prior to Denver Water's review of the water plans following statement and appropriate signature must appear on the cover sheet of the plans (insert the name of the fire department having jurisdiction):

All fire hydrants shall be installed according to Denver Water Standards. The number and location(s) of fire hydrant(s) and fire flow as shown on this water main installation is correct as specified by the _____ Fire Department.

Signature of Fire Chief or Designated Representative

_____ gpm fire flow

Date Signed

e. Contain the signature and stamp of the Professional Engineer licensed in the State of Colorado responsible for the design of the system extension.

7. The specifications shall:

- a. State that the trench shall be excavated and the pipe exposed for inspection at any location on the project if so requested by Denver Water.
- b. State that sterilization and flushing of all mains shall be inspected and certified by the health department having jurisdiction and that one copy of the certification shall be sent to Denver Water. The certification shall state the location of the main that the main has been inspected by a representative of the health department having jurisdiction and was found to comply with the procedures set forth by that department.

B. Submittals shall include the acknowledgment letter described in 2.08.

C. Submittals for PUD/PBG complexes shall additionally show all existing and proposed structures, driveways, and parking facilities, on both the water main plan and the combined plan.

D. Submittal shall include all of the items outlined in Chapter 4 when the granting of easements is required. Partial submittal of those items outlined in Chapter 4 will result in return of the items received.

E. After final approval and prior to construction, the final water main Plans and specifications, per 2.07.A.1. and conforming to the requirements listed below, shall be delivered to Denver Water.

1. An AutoCAD drawing file using the layers, line types, colors, templates, and pen sizes for water facilities as defined on Denver Water's AutoCAD disk, available ROM Denver Water. Drawing submitted on an AutoCAD disk shall be made in model space, not paper space.

2. Overall size of plan submittal shall be 22 inch x 34 inch.
3. The drawings shall be one of the following type and must be legible and of sufficient quality to meet the needs of Denver Water (suitable for microfilming):

All shall be single matte.

An original ink on polyester film.

A photographic polyester film duplicate reverse reading matte front side ("silver slicks" are acceptable).

A wash-off polyester film reverse reading matte front side.

Electrostatic copies on polyester film (reverse reading and coated with clear spray).

Please note: Diazo, polyester film, and sepia are not acceptable.

4. A title block on each sheet in the lower right hand corner, containing pertinent information concerning the map, including the project title, scale, and date. A one inch space shall be left clear under the title block to enable Denver Water to assign each sheet a drawer and number.
5. Lettering shall be mechanical or legible equivalent. Original drawings shall be in ink.
6. Horizontal scale shall not be smaller than one inch equals 40 feet.
7. Aerial photography of the plan view will not be acceptable.

When a conflict occurs between or within standards, specifications and drawings, an interpretation shall be made by the Director of Engineering or an appointed representative pursuant to [1.05](#).

Addenda and modifications to the drawings and specifications take precedence over the original documents. In the drawings, calculated dimensions shall take precedence over scaled dimensions and noted material over graphic indication.

Dedicated streets, easements, and planned development complexes shall conform to the requirements of other sections of these Standards. The copy of the recorded subdivision plat furnished in the final submittal, or a recorded copy of the deed for the property involved, or a recorded copy of an easement shall be furnished to Denver Water as evidence of conformance with [5.09](#).

2.08 Engineering:

All plans and specifications submitted to Denver Water for review, comment, and approval of a system extension or modification shall be prepared by, or under the direct supervision of a Professional Engineer licensed by the State of Colorado. Said Professional Engineer shall be responsible for the design, the plans, determining the material specifications and conducting the field survey. All submitted plans and specifications shall bear the Professional Engineer's seal prior to approval for construction.

The Applicant, Contractor, and Professional Engineer associated with said plans shall be responsible for the adequacy and satisfactory performance of the designs and the

installation of all items therein, and any failure or unsatisfactory performance of the system, so constructed, shall not be a cause for action against Denver Water. Denver Water does not perform engineering services for any person or entity in connection with its review of plans. Approval of plans by Denver Water signifies only that the plans meet the minimum requirements of these Engineering Standards based upon the information provided to Denver Water by the Professional Engineer and/or Applicant/Contractor and makes no finding, representation, or warranty that the system and associated components such as pumps, motors, valves, and meters will perform any certain function.

If the Professional Engineer responsible for the plans disagrees with any changes made to the submitted plans that may be required by Denver Water as a result of Denver Water's review of the plans, such disagreement must be brought to the attention of Denver Water in writing for resolution prior to the construction of the project set forth in said plans. The seal of the Professional Engineer on plans so corrected and approved for construction will signify that he/she has reviewed, approved and authorized said corrected plans for construction.

A signed letter acknowledging that the provisions of this section have been read and understood by the Applicant, Contractor, and Professional Engineer shall be sent to Denver Water along with other submittals required in 2.07.

2.09 Surveying:

Line and grade for water mains shall be established under the direct supervision of a Land Surveyor licensed by the State of Colorado. All work shall be done in a workmanlike manner.

Correct alignment and elevation of the water mains as shown on the approved drawings is the responsibility of the Professional Engineer. Approval of the staked alignment and elevations by Denver Water does not relieve the Professional Engineer in any manner from the responsibility for field errors. Sufficient pipe shall be staked to ensure continual work progress. Under no circumstances shall pipe be installed without line and grade stakes set by the Professional Engineer or Land Surveyor and approved by Denver Water.

Exception: If a main is to be extended in an existing street and if the Professional Engineer who prepared the plans can show that the finished grade of the street is to remain unchanged, no grade stakes need be set. The main shall be installed with a minimum of 4-1/2 feet of cover.

2.10 Placing Survey Lines:

Hubs, stakes, or appropriate survey control markers shall be set on an offset line to mark the location of the centerline of the water main. Centerline hubs and stakes may be used in addition to the offset hubs and stakes; however, they may not be set in place of the offset hubs and stakes. Normal practice is to set offset hubs and stakes 5 to 10 feet off the centerline of the water main.

Offset line points shall be set a maximum distance of 100 feet apart. All valves, crosses, tees, horizontal and vertical bends, and fire hydrants shall be staked for location and grade. Points of curvature and points of tangency of curves, as well as points on the curve, shall be staked for location and grade. All stakes shall be suitably visible.

Stakes shall be positioned so that the offset hub is between the stake and the water main. The side of stake facing the water main shall be marked to show the point being referenced and the distance from the hub to the centerline of the water main. The back side of the stake shall be stationed. Grade stakes shall be set at each hub and shall state the vertical distance from the top of the hub to the top of the pipe. This vertical distance will be based on the fact that the distance from the official street elevation to the top of the pipe shall be a minimum of 4-1/2 feet.

Denver Water shall not supervise nor set out work or give line and grade stakes.

2.11 Inspection:

Installation of all new facilities in the City and County of Denver, in Total Service Areas, and in Distributor Contract Areas shall be inspected and approved by Denver Water.

Denver Water personnel are not responsible for Contractor work site safety compliance or enforcement of applicable safety regulations and standards, including OSHA compliance regulations at or on the work site.

Denver Water shall ensure that the provisions of the Engineering Standards are carefully complied with, especially with regard to the quality of workmanship and materials. Problems, which may require sound field judgment, in lieu of strict interpretation of the Engineering Standards, shall be resolved by the Professional Engineer and the Contractor to the satisfaction of Denver Water.

All work shall be performed in accordance with these Engineering Standards. Any work not accepted by Denver Water shall be redone until compliance with these Engineering Standards is achieved.

All appropriate permits shall be on the jobsite and shall be checked by Denver Water before starting construction.

Orders given by Denver Water relating to quality of materials and workmanship shall be obeyed at once by the Contractor.

All materials used shall be subject to the inspection and approval of Denver Water at all times, and shall not be used before being inspected and approved by Denver Water. Denver Water has the right to perform any testing deemed necessary to ensure compliance of the material with these Standards. Failure or neglect on the part of Denver Water to condemn or reject work or materials not in accordance with these Engineering Standards, shall not be construed to imply their acceptance should their inferiority become evident at any time. Materials rejected by Denver Water shall be immediately removed from the jobsite.

After receipt of approved plans from Denver Water, the Contractor shall give at least 48 hours notice to Denver Water (303-628-6627) immediately prior to starting construction. No construction shall commence within 48 hours after receipt of approved plans.

2.12 Contractors:

No work shall commence until the pre-construction meeting [2.06.J](#) has been conducted and the Contractor has an approved set of plans and specifications in his possession. All work shall be performed in strict compliance with the approved plans and specifications.

Contractors or sub-contractors performing all work for both main extensions and private pipe extensions shall be competent, licensed firms with adequate manpower and equipment to accomplish the work in accordance with these Engineering Standards and applicable OSHA Standards. A representative of the Contractor shall be present at the jobsite whenever work is being conducted by sub-contractors.

Contractors installing main extensions within the City and County of Denver and Total Service Areas must meet additional requirements with regard to qualification, bonding, and guarantees.

A. Qualification: Contractors desiring to construct water main systems inside the City and County of Denver or for Denver Water's Total Service Districts must be pre-qualified. Pre-qualification forms may be obtained from, and returned to, Denver Water. Following evaluation of the completed form, written notice of acceptance or denial will be transmitted to the Contractor. Pre-qualification is subject to yearly application and renewal.

B. Bonding: Contractors pre-qualified by Denver Water shall post a \$5,000 maintenance bond with Denver Water for each main installation. The bond shall be in effect for the period of one year. At the end of the period of one year, the Contractor's work shall be reviewed and evaluated. The Contractor's bond may be revoked or renewed for an additional year depending upon the evaluation.

The purpose of the bond is to provide protection to Denver Water for any expenses it may incur as a result of:

1. Repairs or work performed by Denver Water caused by the Contractor.
2. Necessary repairs caused by the installation of defective material.
3. Necessary repairs caused by poor installation techniques.
4. Material and mechanic's liens against Denver Water.
5. Costs incurred by Denver Water due to the Contractor's failure to perform in accordance with the Engineering Standards.

The surety for bond shall be acceptable to Denver Water.

C. Guarantee of Workmanship, Materials, and Equipment: The Contractor and Surety on the Maintenance Bond shall be jointly responsible for a period of one year following the final acceptance of all work performed for the satisfactory repair or replacement of all work, material, services, and equipment which becomes defective during this period, as a result of faulty materials, faulty installation, or improper handling of material and equipment installed by the Contractor.

2.13 Points Of Delivery:

Denver Water will deliver water from a point on its facilities that is the nearest available, adequate, and feasible for the connection. Denver Water's determination of this point shall be final.

2.14 Special Conditions:

When applying for a main extension, special conditions that involve another agency, such

as crossing a railroad, ditch or a highway, may exist. All conditions of the other agency must be satisfied. All designs, drawings, and calculations submitted to another agency shall also be submitted to Denver Water for approval. Should a conflict in the plans and specifications occur between Denver Water and the other agency, the more stringent plans and specifications yielding a higher quality product, as determined jointly by Denver Water and the other agency, shall prevail.

2.15 Exceptions Under Chapter 2:

Inside the City and County of Denver and Total Service Areas, notwithstanding these procedures, Denver Water reserves the right to install mains when to do so is in the best interest of Denver Water. This determination is solely at the discretion of Denver Water.

The Applicant shall pay all costs for extending mains whether installed by the Applicant's Contractor or by Denver Water.

*Engineering Standards - Chapter 2:
Revised 07-04, Previous Revision 05-02
End*

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 3 – Service Lines And Appurtenances

3.01 General:

Water is conveyed from mains to Customers by service lines and their appurtenances. In the context of these Standards, service lines include all pipe and fittings up to and including the stop and waste valve in the residence for outside meter settings, and up to and including the valve at the downstream side of the meter for inside settings as shown on Sheets 48 and 50 of the [Standard Drawings](#). All water pipe beyond service lines shall be controlled by the local plumbing codes.

All new or replacement service lines and appurtenant fittings installed in areas being supplied with recycled or potable water from Denver Water shall conform to the following minimum standards which shall be binding regardless of the regulations of any other agency covering like installations.

The corporation stop, the meter, and that portion of the service line between the meter and the corporation stop and 5 feet past the meter shall all be of the same size. From this point through the inside valve, service lines may be increased one pipe size.

3.02 Ownership And Maintenance:

Chapters 6, 7, and 9 of the [Operating Rules](#) of the Board of Water Commissioners deal extensively with ownership, installation, and maintenance of service lines, meters, and appurtenances. These Engineering Standards are intended to be supplemental and subordinate to the Operating Rules and will be so construed in any conflicting situations.

A. Ownership: The service line and fittings through which a licensee receives water service from the facilities of Denver Water shall be owned by and installed at the expense of the licensee.

B. Maintenance: The owner shall maintain all privately owned piping except as set forth under the referenced Operating Rules. This shall include the service line and all fittings and fixtures, except the water meter.

The curb stop, service box, and meter pit shall be kept conveniently accessible from street side and shall be clear of trees, shrubs, and bushes a minimum of two feet around the meter pit, in good working order, and properly capped and clean of debris. Any box or pit not conforming to these Standards shall be cleaned, repaired or relocated by the owner of the premises within a reasonable time after

notification by Denver Water. Failure by the owner to comply may cause Denver Water to do the necessary maintenance work and charge the cost to the premises served.

C. Frozen Service Lines and Stub-In Connections: Denver Water will not be responsible for the thawing of frozen service lines or appurtenances or repair to stub-in connections installed to permit street paving.

D. Repair Services Available:

Inside Denver And Total Service Areas:

Denver Water will provide limited repair services to the segment of the service line located between the main and the outlet side of the curb stop or where no curb stop has been installed, the valve in the meter pit or the property line as appropriate. This service shall be made available only to licensed premises located inside of Denver or the Total Service Areas and shall consist of the following:

1. The repair of leaks on service lines with curb stops, which originate between the water main and the outlet side of the curb stop.
2. The repair of leaks on service lines having outside meter setting and no curb stop originating between the water main and the outlet side of the meter.
3. The repair of leaks on service lines not having curb stops or outside meter setting which originate between the water main and the customer's property line.
4. The repair of leaks on service lines connected to privately owned firelines as set forth above in addition to leaks originating on the fireline between the main and the inlet side of the fireline property line valve.

Denver Water shall in no instance perform the repairs described above unless Denver Water has actual notice of the leak and Denver Water determines that sufficient manpower and equipment are available to make the repairs. Any service line items replaced or installed by Denver Water while repairing a leak on a segment of the service line maintained by Denver Water, shall become the property of the owner of the premises.

The customer shall retain total responsibility for repair of all leaks from any segment of the service line or its appurtenances, which are not within the boundaries described above. Any such leak shall be repaired by a licensed and bonded plumber, without delay, at the owner's expense. In the event the leak is of a serious nature or has not been repaired within a reasonable time, the service line may be shut off at either the curb stop or the main and service discontinued until the service line has been repaired.

Master Meter And Read And Bill Distributor Contract Areas:

The customer shall retain total responsibility for repair of all leaks from any segment of the service line or its appurtenances. Any such leak shall be repaired by a licensed and bonded plumber, without delay, at the owner's expense. In the

event the leak is of a serious nature or has not been repaired within a reasonable time, the service line may be shut off at either the curb stop or the main and service discontinued until the service line has been repaired.

3.03 Layout:

The general arrangement of all service lines shall be as follows:

A. Location: That portion of the service line between the main and the property line or stop box shall be in a continuous straight line perpendicular to the main.

The main to be tapped must extend a minimum distance of 8 feet along the front lot line of the property to be served, and the service line connection and service must be a minimum of 5 feet into the lot.

In the case of corner lots the property may be served from the side lot line under the same regulations as above.

If service is requested for lots at the end of a cul-de-sac street, the main to be tapped must be not more than 50 feet from any property line in the cul-de-sac. The service line between the main and the property line shall be in a continuous straight line and shall enter the property a minimum distance of 5 feet from the nearest lot corner.

B. Depth: All service lines shall be installed at least 4-1/2 feet below the official street grade and in all other places at least 4-1/2 feet below the surface of the ground. If, in the judgment of Denver Water, the topography of the area indicates the advisability thereof, the service line shall be installed at lower depths.

If, after a service line has been installed, the grade of the surface of the ground is lowered, the property owner shall have a licensed and bonded plumber lower or relocate his service line so as to maintain a minimum cover of 4-1/2 feet.

C. Compaction: Backfill material shall be carefully compacted in accordance with the requirements of [7.11](#).

D. Length: For inside meter settings, that portion of the service line between the main and the meter shall not exceed a horizontal length of 60 feet without approval of Denver Water.

3.04 Separate Trenches:

Service lines may not be installed in trenches containing pipes, which carry any substance other than potable water, and a service line shall be separated laterally from foreign pipes by a minimum of 10 feet.

Exception:

A service line may be placed in the same trench with other pipe provided the following conditions are met:

1. The foreign pipe shall be cast iron or ductile iron.
2. The bottom of the service line shall be at least 12 inches above the top of the foreign pipe and shall be placed on a shelf excavated on one side of the

common trench.

3.05 Combination Service Lines:

A property requiring a domestic service line and a fireline connection may be served from a single tap in some cases. The fireline connection shall extend straight from the main to the property line and shall have a gate valve located 2 feet minimum from the property line on the street side of the property line. A tee shall be placed on the fireline connection on the inlet side of the gate valve for the domestic service line. No more than one domestic service connection (tap or tee) shall be installed on a fireline connection. A domestic service tee may not be placed on an existing fireline. See Sheet 36 of the [Standard Drawings](#) and [6.37](#) and [8.17](#).

3.06 Pumps:

Except where specifically authorized by Denver Water, the installation of pumps designed to increase water pressure in service lines is prohibited.

3.07 Tanks:

Tanks shall not be allowed for the sole purpose of decreasing the size of the tap/meter and service line.

3.08 Connections For Water:

All connections for domestic service taps, 2 inches and smaller, shall be made by Denver Water, unless provided otherwise by contract. Connections will be made only after the release of the mains by Denver Water following completion of the conditions and tests outlined in [8.27](#), payment of appropriate fees, completion of the tap application papers, and the service line is laid in place from main and up to and including the curb stop by a plumber or a licensed water service contractor. Any excavation necessary for making the connection shall be completed prior to the arrival of Denver Water.

Fireline connections inside Denver and Total Service Areas, greater than 2 inches, shall be made by Denver Water.

Exception:

Contractors installing mains may also install firelines and tee connections for domestic service lines provided the connections involved are larger than 2 inches, and provided that the service line is installed in conjunction with the main extension. Such an installation is subject to proper release of tap application papers, payment of appropriate fees, and approval of the appropriate Fire Protection Bureau. See [8.27](#) for acceptance of mains.

All domestic service taps larger than 2 inches may be installed by Denver Water or by a Contractor. For Denver Water installed connections, the Contractor shall excavate the ditch and shall excavate around the water main so as to expose it on all sides. Denver Water will provide and install the tapping saddle, tapping sleeve, or cut-in tee at cost. The Contractor shall connect to the outlet, install the piping, set the valve boxes and backfill the trench.

Domestic service lines 2 inches and smaller shall be by corporation stop of the same size as the service line and meter to be installed. Corporation stops shall be as specified in

[6.38](#). Service connections to the main for service lines larger than 2 inches shall be by a tee connection. All tapping materials shall be provided by the Owner.

Domestic service lines of dissimilar metals shall be electrically insulated by means of a Denver Water approved insulating fitting or gasket. Care shall be taken to properly install corporation stops and provide enough slack in service lines to protect against pullout problems.

Under no circumstances is a machined-over-all (MOA) asbestos-cement pipe to receive a corporation stop.

In tapping mains directly, it may be necessary to dig out bedding material and apply two or three wraps of adhesive tape completely around the polyethylene encased pipe to cover the area where the tapping machine and chain will be mounted. This method minimizes possible damage to the polyethylene during the direct tapping procedure. After the tapping machine is mounted, the corporation stop is installed directly through the tape and polyethylene. After the direct tap is completed, the entire circumferential area shall be closely inspected for damage and repaired if needed. Any bedding material removed during excavation shall be replaced in kind and compacted in accordance with [7.10](#).

3.09 Taps And Saddles:

The size of tap and the tapping method for a given type and size of water line shall be as follows:

Tapping saddles with tap size 2 inches and smaller for ductile iron and asbestos-cement pipe shall consist of a bronze body with 2 bronze straps. Saddles for PVC shall be single strap bronze saddle.

Taps 2 inch and smaller shall not be allowed in PVC pipe which contains water under pressure. In Master Meter and Read and Bill Distributor Contract areas, the Distributor will be given the option to perform the required operations to eliminate pressure to the pipeline being tapped. Denver Water will perform the operations inside Denver and Total Service Areas. A fee per tap will be charged by Denver Water for performing the operations required to eliminate pressure in the PVC pipeline.

Existing steel mains 20 inches in diameter or less, shall be tapped using a method approved by Denver Water.

See [MS-22](#), for further information on tapping saddles.

3.10 Size:

A. General: Taps and service lines shall be of a size, which is adequate to supply all the requirements of the property being served. The minimum size allowable for a service line shall be 3/4 inch.

The tap, corporation stop, meter, and that portion of the service line between the meter and the corporation stop and 5 feet past the meter shall all be of the same size. The service line may be increased beginning 5 feet downstream of the meter to the next approved larger pipe diameter.

The size for a service line shall be defined in terms of headloss as follows: The total pressure drop in the service line from the main to the building shall not

exceed 25 psi without backflow prevention or 35 psi with backflow prevention at peak demand (including all minor losses), a minimum residual pressure of 20 psi at the building beyond any back flow prevention and a peak demand not exceeding 80% of the maximum meter capacity.

B. Single Family Residences: The minimum tap size for a single-family residence shall be 3/4 inch.

C. Multi-Family Buildings: In addition to the general requirements, the minimum tap size shall also be based on the number of units per building, as follows:

2-6 units 3/4 inch

7-12 units 1 inch

13-24 units 1-1/2 inch

25-40 units 2 inch

Over 40 units will be evaluated on an individual basis. In special circumstances, Denver Water may require a larger minimum tap size. If Distributors require a larger minimum tap size, the Distributor's requirement shall apply in lieu of the tap size in this Section.

3.11 Pipe Material:

All service lines supplying water from Denver Water's system shall conform to one of the following specifications. Plastic composite pipe is not an acceptable service line material.

A. Seamless Copper Tube of the type designated in the industry as Type K; soft, shall be used for service lines 3/4 inch through 2 inches.

B. Ductile Iron Pipe conforming to [MS-1](#), and shall be used for all service lines larger than 3 inches.

3.12 Curb Stops, Valves, And Valve Boxes:

A curb stop or gate valve of the same size as the service line and conforming to the following standards shall be installed on every service line at a point at or near the property line. Curb stops 2 inches and smaller shall conform to [MS-21](#). Gate valves 3 inches and larger shall conform to [8.12](#), [MS-4](#), and [MS-4A](#).

All buried valves and curb stops shall be equipped with a cast iron valve box and large oval base. See [6.12](#) and [MS-11](#) for valve boxes and [6.40](#) and [MS-22](#) for curb stop services boxes.

See [6.23](#) and [MS-21](#) for requirements on valves used with meters.

3.13 Meters:

Meters and appurtenances are discussed in detail in [6.14](#) through [6.27](#). Meters which are read for billing purposes by Denver Water shall be owned by, and installed at the expense of, the property owner served by such meter. The exception occurs when the Board installs meters at its own expense to convert unmetered services to metered services. In this case, the meters are owned by the Board.

A. Inside Setting Installation: All inside meter settings shall be equipped with an approved meter, and an Itron Remote ERT with 20-foot signal cable. Inside meter settings are permitted only when the total length of service line from the main to the meter setting does not exceed 60 feet.

B. Outside Setting, Vault Installation: All outside meter settings in vaults, 1-1/2 inch and larger, shall be equipped with an approved meter and an Itron ERT for each meter register. Denver Water shall determine the use of pit ERTs or remote ERTs on a case-by-case basis. All drawings shall be approved by Denver Water's Customer Service Field Section prior to installation.

C. Outside Setting, Pit Installation: All outside meter settings in pits (5/8 inch, 3/4 inch and one inch) shall be equipped with an approved meter with a direct read register and an Itron ERT.

D. Outside Settings with Remote ERTs: If necessary to obtain drive-by readings from a public street, remote ERTs may be required for outside meter settings. In such cases, an approved signal cable shall be installed in a conduit from the meter setting to the location inside or outside the building designated by Denver Water, and a suitable mounting system provided for the Itron Remote ERT.

If necessary, for obtaining meter readings from a public street, the developer of a new complex may be required to install additional electronic equipment to collect and relay meter reading data. Adequate mounting locations and electric power shall be furnished as required.

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 4 – Easements And Licenses

4.01 General:

The following procedures have been developed to process easement and revocable licenses as quickly as possible through Denver Water. These procedures have been developed for the ease of administration and to provide Denver Water with accurate and uniform drawings, legal documents, and specifications. Requests that do not follow these procedures and required attachments will not be considered.

4.02 Granting An Easement To Denver Water:

When a developer or property owner is required to grant permanent easements to Denver Water for the installation of water mains, the following procedures shall be followed:

A. Procedure: The following items shall be submitted in one complete package to Denver Water's Water Sales Section with the initial submittal of water plans as described in Section [2.05](#).

Partial submittals or those not conforming to these requirements will be returned to the submitting party with a request to complete the submittal. The Plan Review process will not begin until all items have been received.

1. A letter requesting that Denver Water accept the easement indicating the full and legal name of the property owner granting the easement and the names and titles of the persons authorized to sign the easement agreement and those who will attest the authorized signer, if applicable.
2. An AutoCAD drawing file made in model space, **NOT** paper space using the layers, line types, colors, templates, and pen sizes as defined in Section [4.06](#).

Drawings that do not comply with Section [4.06](#) are not acceptable.

- a. Size: Overall 8-1/2 x 11 inches as shown on Specimen B of Section [4.06](#).
- b. Title Block: Dimensions and lettering as shown on Specimen B of Section [4.06](#). The initials of the person who prepared the drawing shall be entered in the area marked "DRN." All other fields will be completed by Denver Water.

c. Scale: The drawing shall be to an appropriate recognized civil engineering scale. The scale used shall be large enough so that all dimensions are clearly shown. Whenever possible, the entire easement should be on one sheet. Break lines, except in the land corner, ties, are not acceptable.

d. Tie: All parcels shall have a direct tie, or one with a maximum of two courses, to the nearest available recognized land corner (i.e., section corner, quarter section corner, range point). If the easement is located within a platted subdivision, a tie shall be made to a lot corner, tract corner, or subdivision corner of that subdivision.

Basis of bearings shall be established using NAD83 State Plane Coordinates, with the State Plane Coordinate information clearly identified on the AutoCAD drawing.

e. All distances shown on the drawing shall be to the nearest hundredth of a foot.

f. A description of the monuments set at the ends of the line, which is the basis of the bearing, shall be supplied in the drawing or the bearing basis note.

3. A Commitment for Title Insurance covering the water line easement indicating the "City and County of Denver, acting by and through its Denver Board of Water Commissioners" as the proposed insured shall be submitted. The following items shall be included:

a. Legible copies of all documents referred to in the B-2 (Exceptions) portion of the Commitment for Title Insurance. Documents must be submitted in the order identified on the title commitment. Documents shall be numbered to coincide with the number indicated on the title commitment.

b. A drawing or map depicting the water line easement and all of the exceptions that can be plotted. Exceptions on the drawing or map shall be numbered correlative to the number of the exception on the Commitment for Title Insurance.

c. Denver Water will determine the amount of title insurance to be acquired. All expenses incurred in obtaining title insurance shall be paid by the grantor of the easement.

d. A title insurance policy shall be submitted to Denver Water's Property Management Section upon finalization of the easement document and the Commitment for Title Insurance review.

e. Title Commitments and policies are NOT REQUIRED for 10' wide fire hydrant easements that stand alone as additions to existing waterline easements or a dedicated right-of-way. Ten foot wide fire hydrant easements being granted as a part of a proposed distribution line easement shall be included in the title commitment/policy for the overall easement.

4. A copy of an overall site plan, which accurately shows the relationship of the following:

- a. The proposed water main, easement, and dedicated rights-of-way.
 - b. All existing and proposed utilities on the site.
 - c. Proposed structures, landscaping, and roadways on the site.
 - d. Cross-sections of private roadways which are coincidental with water line easements and cross sections of public rights-of-way within which a water main is to be installed.
 - e. The perimeter distances and bearings or angles of the site and its relationship to the tie corner of the easement.
5. A copy of a recorded or preliminary subdivision plat or development plan for the area or subdivision within which the water line easement is located, or any subdivision plat or a Planned Unit Development plan that directly relates to the easement(s) and depicts property boundaries.

B. Document Preparation: Denver Water will prepare the easement agreement on a standard Denver Water form and return the document to the grantor for signatures.

Denver Water will prepare all easement agreement documents for easements acquired on property within the City and County of Denver and in Total Service Contract Service Areas. A "Duplicate Document Preparation Fee" of \$1,000.00 may be charged by Property Management for agreements requiring more than one preparation, or for title work that must be re-reviewed because of a conveyance of the property or if other significant modifications are required during preparation.

C. Construction: The construction of the water main shall not be authorized to commence until the easement is accepted by Denver Water, the easement agreement has been recorded, and the title insurance policy and any documentation incidental thereto has been received and reviewed.

4.03 Granting An Easement To A Distributor:

For developments located outside the City and County of Denver, but inside a Denver Water Distributor's Contract Service Area, a completed, recorded easement agreement on one of the four Denver Water approved, pre-printed distributor easement documents ("Non-Exclusive", "Exclusive" or "PUD/PBG", or, for those Distributors meeting the qualifications set by Denver Water, the "Distributor" Non-Exclusive Performance Easement") shall be submitted to Denver Water prior to the approval of the water plans.

Criteria for drawings and legal descriptions attached to the easement agreements are established by the individual distributor.

All other criteria for easements (widths, easement types and private roadway templates) are as indicated in these Engineering Standards.

4.04 Obtaining A License To Use Or Cross Denver Water Property:

When requesting permission to use or cross Denver Water property, an Applicant shall request a revocable license for routine right angle utility crossings of strip properties and easements, or for temporary uses. The following procedures shall be followed:

A. Procedure: A letter requesting Denver Water's permission to use or cross its property shall be submitted to Denver Water's Property Management Section. The letter of request shall contain the exact name of the company, corporation, partnership, etc., that will own, operate, and maintain the proposed facilities, the names and titles of the persons authorized to sign the agreement, and include the following enclosures:

1. An AutoCAD drawing file made in model space, NOT paper space, using the layers, line types, colors, templates, and pen sizes as defined in Section [4.06](#).

Drawings that do not comply with Section [4.06](#) are not acceptable:

- a. Size: Overall 8-1/2 x 11 inches as shown on Specimen B of Section [4.06](#).
- b. Title Block: Dimensions and lettering shown on Specimen B of Section [4.06](#). The initials of the person who prepared the drawing shall be entered in the area marked "DRN." All other fields will be completed by Denver Water.
- c. Scale: The drawings shall be to an appropriate recognized engineering scale. The scale used must be large enough so that all dimensions are clearly shown. Whenever possible, the entire crossing should be on one drawing. Break lines, except in the land corner ties are not acceptable.
- d. Tie: All crossings shall have a direct tie, or one with a maximum of two courses, to the nearest available recognized land corner (i.e., section corner, quarter section corner, range point, Denver Water monument, or the nearest available intersection of two dedicated public road right-of-way lines).

Basis of bearings shall be established using NAD83 State Plane Coordinates, with the State Plane Coordinate information clearly identified on the AutoCAD drawing.

- e. All distances shown on the drawing shall be to the nearest hundredth of a foot.
- f. All drawings shall have a typical profile of the crossing as shown on the specimens.

2. A check payable to Denver Water for the applicable fee shall accompany the letter of request. If the request for the License Agreement, after Denver Water's review, is denied, one-half of the applicable, then-current licensing fee will be returned. The remaining half will be retained to cover associated review and administrative costs.

3. Requests should include prints of the plans of the overall job in the area of the crossing, when available, and prints of new or proposed subdivisions whenever this information would clarify or identify the location of the request.

B. Fees:

1. License Agreements for routine right angle utility crossing of Denver

Water strip properties are issued for a one-time license processing fee. This license processing fee is established by Denver Water's Property Management Section. The fee for the use of Denver Water property, other than for a routine right angle utility crossing, will be determined by Denver Water using accepted real estate appraisal practices.

2. Upon request, the required drawing will be prepared by Denver Water, provided all necessary information is included with the request. Substantial delay in issuance of authorization may be experienced if Denver Water prepares the drawings. Planning on the part of the requestor should include these potential delays.

The fee for Denver Water's preparation of the drawing is established by Denver Water's Property Management Section in addition to the then-current processing fee.

3. A deposit shall be collected from Licensee prior to the issuance of any License Agreement on the Board's High Line Canal property. The deposit shall be refunded only upon complete restoration of the Board's property to the Board's satisfaction following construction.

C. Document Preparation: Denver Water will prepare the License Agreement on a standard Denver Water License Agreement form and return the document to the Licensee for signatures. A copy of the completed Licensed Agreement shall be kept at the job site at all times.

4.05 Acquiring An Easement From Denver Water:

When a utility company, municipality or other entity desires to obtain the permanent right to use or cross Denver Water property, the following procedures shall be followed.

A. Procedure: A letter requesting that Denver Water grant an easement shall be submitted to Denver Water's Property Management Section. The letter shall contain the name of the entity to whom the easement will be granted and include the following enclosures:

1. An AutoCAD drawing file made in model space, **not** paper space using the layers, line types, colors, templates, and pen sizes as defined in Section [4.06](#).

Note: Drawings that do not comply with Section [4.06](#) are not acceptable.

a. Size: Overall 8-1/2 x 11 inches, as shown on Specimen B of Section [4.06](#). inch

b. Title Block: Dimensions and lettering as shown Specimen B of Section [4.06](#). The initials of the person who prepared the drawing shall be entered in the area marked "DRN." All other fields will be completed by Denver Water.

c. Scale: The drawing shall be to an appropriate recognized engineering scale. The scale used must be large enough so that all dimensions are clearly shown. Whenever possible, the entire easement should be on

one sheet. Break lines, except in the land corner ties, are not acceptable.

d. Tie: All parcels shall have a direct tie, or one with a maximum of two courses, to the nearest available recognized land corner (i.e., section corner, quarter section corner, range point). If the easement is located within a plotted subdivision, a tie shall be made to a lot corner, tract corner, or subdivision corner of that subdivision.

Basis of bearings shall be established using NAD83 State Plane Coordinates, with the State Plane Coordinate information clearly identified on the AutoCAD drawing.

e. All distances shown on the drawing shall be to the nearest hundredth of a foot.

f. A description of the monuments set at the ends of the line, which is the basis of the bearing, shall be supplied in the drawing or the bearing note.

2. Two copies of the overall construction plans, which accurately show the following:

a. Any existing roadway and/or bridge.

b. The proposed facilities (i.e., roadway and/or bridge or utility).

c. The proposed construction area.

d. Any proposed temporary easement area.

e. Existing and proposed fencing.

f. All Denver Water facilities in the area.

B. Valuation: A Denver Water staff appraiser will appraise the requested easement. The minimum cost for the granting of a permanent easement is established by Denver Water's Property Management Section.

C. Fees: A deposit shall be collected from Grantee prior to the conveyance of any Easement Agreement on the Board's High Line Canal property. The deposit shall be refunded only upon complete restoration of the Board's property to the Board's satisfaction following construction.

D. Document Preparation: Denver Water will prepare the necessary documents and forward them to the grantee for signature.

E. Construction: No construction will be authorized to commence until a final easement is granted.

4.06 Specimen Sheets Illustrating Procedures:

	CAD	PDF
<i>General Instructions</i>	<u>4-06</u>	<u>4-06</u>
A. DW Standards	<u>4-06A</u>	<u>4-06A</u>
B. Border/Title Block	<u>4-06B</u>	<u>4-06B</u>
C. Perimeter Description	<u>4-06C</u>	<u>4-06C</u>
D. Crossing Overhead	<u>4-06D</u>	<u>4-06D</u>

E. Underground Ditch Crossing	<u>4-06E</u>	<u>4-06E</u>
F. Centerline Description	<u>4-06F</u>	<u>4-06F</u>
G. Simplified Area	<u>4-06G</u>	<u>4-06G</u>
H. Fire Hydrant Easement	<u>4-06H</u>	<u>4-06H</u>

Engineering Standards - Chapter 4:
Revised 07-04, Previous Revision 05-02
End

(GENERAL INSTRUCTIONS)

INSTRUCTION FOR THE PREPARATION OF DENVER WATER EXHIBIT DRAWINGS

- 1) The purpose of the drawing is to clearly show the easement area or the location of the item to be licensed and the area immediately surrounding it.
- 2) Submitted Auto CAD files must be done in MODEL space only. No X-referencing is allowed.

Use the provided layers only do not change layer names or layer colors.
- 3) The LINE TYPE scale and DRAWING scale must be the same.
- 4) All text sizes are based on the Simplex text style and the TXT_10 being 1/10 of an inch high. Except for the Shadow Font. No substitutions for the Simplex template are allowed. The Shadow font Shadow.SHX is included with this standards package.
- 5) The North direction and arrow must be in the range from 90° to the left to 45° to the right. Having "North" at the top of the page is preferred. The 8 1/2" side of the drawing is always the bottom of the page.
- 6) The tie should be to a monumented corner of the quarter section in which the easement parcel or licensed item lies. A direct tie is preferred but a tie with a maximum of two courses will be accepted.
- 7) All designations for quarter section lines and land corners must be for the quarter section in which they lie. Place them within that quarter section.
- 8) Basis of Bearings: Note that the bearing basis has three parts:
 - 1) Numeric value: deg. min. sec.;
 - 2) Monumentation: The monuments used for the bearing basis must be shown on the parcel map or described in the Basis of Bearing Note.
 - 3) Source of Basis: Denver Metro Area, State Plane Central Zone(Metro Grid): Outside the Metro Area, Subdivision Plat, or existing Denver Water Maps.
 - Denver Water requires two monumented corners for the Basis of Bearings.
 - Licensed items may be tied to the nearest DWD monument when available.
- 9) A 0.06" tick mark must be used to delineate the end points of curves and angle points if its location is not obvious. Rotate tick marks to be radial to the curve or to bi-sect the angle and place them on the TXT_08 layer.
- 10) "Easement Hatching Lines". Hatch lines must be spaced 0.06" apart. (The Hatch Scale equals .48 times the drawing scale) The hatch angle must be 45° or 135° to match the Legend. Use the DWD Hatch Layer for all hatch lines.
- 11) Show the easement or property area in square feet and "round" it to the nearest foot if the area is less than one half acre. Show the easement or property area in acres and to three decimal places if the area is one half acre or more. i.e., 21,779 sq. ft. or 4.503 acres.
- 12) The initials of the person who prepared the drawing should be entered in the area marked "DRN.". All other fields will be completed by Denver Water.
- 13) General information:
 - All Z coordinates must be Zero.
 - Files must not be Zipped if they will fit on a CD.
 - The use of course tables should be avoided.
 - Label the quarter/quarter for each one shown on the parcel map.
 - Include a Bar Scale that matches the DWD standard of 1/10 of an inch by 3".
 - Drawing accuracy
All lines and curves must be drawn accurately to two decimal places for distance and to one half second for bearings.
 - When multiple easement parcels exist they must be separated by the type of easement document being used and grouped by owners.
- 14) Specimen_G should only be used when requesting a license for an irregular area for a use such as grading, rip rap, or a lawn irrigation system. The perimeter should be simplified to avoid using multiple small courses.

LEGEND		DOCUMENT DATED SEC'Y FILE DOC.		D DENVER WATER	
	BOUNDARY D.W.D. PROPERTY	RIMS ITEM NO.		LEAVE THIS SPACE BLANK	
	BNDRY EXISTING D.W.D. ESMT	CARD NO.			
	EASEMENT/PROPERTY ACQUIRED	DRN. ZYX	PM. — S.		
	ESMT/PROP/LIC GRANTED	APPD		DATE: SEPTEMBER 1, 2004	
		SHEET 1 OF 8 SHEETS		SCALE: 1" = 1'	CAD

(CAD SPECIMEN_A)

STANDARDS

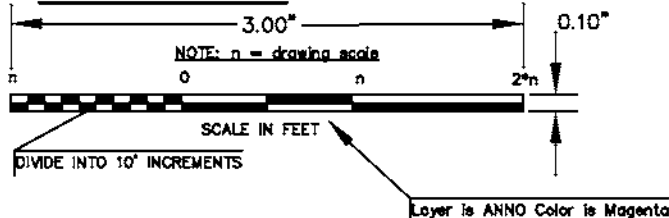
DRAWING NOT TO SCALE

LAYER NAME	LINE WEIGHT	LAYER COLOR	LAYER NAME	SIMPLEX TEXT STYLE	LAYER COLOR
ANNO	0.010 IN.	MAGENTA	TXT_05	L50	210 (magenta)
BLD_FOOTPRINT	0.010 IN.	MAGENTA	TXT_06	L60	210 (magenta)
BORDER	0.035 IN.	WHITE	TXT_08	L80	210 (magenta)
LN_CNTRLN	0.010 IN.	MAGENTA	TXT_10	L100	160 (blue)
EASMT_ACQ_BNDY	0.021 IN.	RED	TXT_12	L120	70 (green)
EXT_LN_DWDROW	0.043 IN.	YELLOW	TXT_14	L140	10 (red)
EXT_LN_DWDPROP	0.043 IN.	YELLOW	TXT_12SH	L120SH	210 (magenta)
FACILITY_PROFILE	0.010 IN.	MAGENTA	TXT_175SH	L175SH	210 (magenta)
HATCH	0.010 IN.	MAGENTA			
HEADGATE	0.010 IN.	MAGENTA			
LIC_CNTR_LN	0.043 IN.	YELLOW			
LOT_LN	0.010 IN.	MAGENTA			
MONUMENTS	0.010 IN.	MAGENTA			
NOTES	0.010 IN.	MAGENTA			
EXT_OWNERSHIP	0.010 IN.	MAGENTA			
EXT_ESMT-Other	0.010 IN.	MAGENTA			
PARKING_LOTS&ISLANDS	0.010 IN.	MAGENTA			
RIVERLN	0.013 IN.	BLUE			
EXT_LN_SEC-16TH	0.010 IN.	MAGENTA			
EXT_LN_SEC-64TH	0.010 IN.	MAGENTA			
EXT_LN_SEC-FULL	0.010 IN.	MAGENTA			
EXT_LN_SEC-QUARTER	0.010 IN.	MAGENTA			
SECCOR	0.010 IN.	MAGENTA			
STREET_R-O-W_LN	0.017 IN.	GREEN			

LINETYPES

DWDROW	---
DWDPROP	---
CENTERLN	---
SEC_QUARTER	---
SEC_FULL	---
SEC_16th	---
SEC_64th	---
RIVERLN	---

STANDARD GRAPHIC SCALE



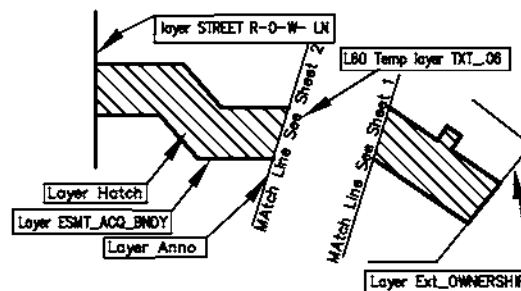
Only Scales in Multiples of 10 are acceptable i.e., 10, 20, 30...

CAD Layer TXT_08
L80 Temp Layer TXT_08
CAD Temp L80

STANDARD SYMBOLS

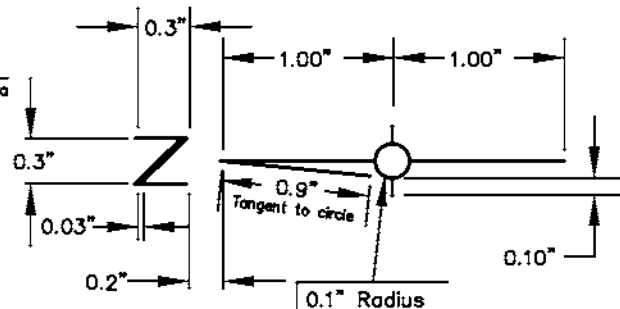
SYMBOL	NAME	LAYER
	SEC COR	SECCOR
	HEAD GATE	HEADGATE
	BREAK LINE	LAYER (VARIES)

SAMPLE MATHC LINE



NORTH ARROW

See note 5) Instructions



LEGEND

	BOUNDARY D.W.D. PROPERTY
	BNDRY EXISTING D.W.D. ESMT
	EASEMENT/PROPERTY ACQUIRED
	EASEMENT/PROPERTY GRANTED

DOCUMENT DATED
SEC'y FILE DOC.
RIMS ITEM NO.
CARD NO.

DRN. Zyx PM. S.
APPD
SHEET 2 OF 8 SHEETS

D DENVER WATER

LEAVE THIS SPACE BLANK

DATE: SEPTEMBER 1, 2004

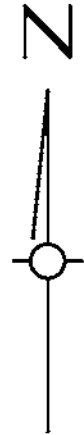
SCALE: 1" = 1'

CAD

(SPECIMEN_B)

BORDER/TITLE BLOCK
DRAWING NOT TO SCALE

NN 1/4 SECTION ##, TOWNSHIP # SOUTH, RANGE ## WEST 6th P M
----- CITY AND COUNTY OF DENVER -----



10.22"

7.92"

PARCEL CONTAINS #### ACRES±

LEGEND		D DENVER WATER	
	BOUNDARY D.W.D. PROPERTY	SEC'Y FILE	DOC.
	BOUNDARY D.W.D. EASEMENT	RIMS ITEM NO.	
	EASEMENT ACQUIRED	CARD NO.	
	EASMT/PROP/LIC/GRANTED	DRN. ZYX	PM. — S.
		APPD	DATE: SEPTEMBER 1, 2004
		SHEET 3 OF 8 SHEETS	SCALE: 1" = 100'
		CAD	

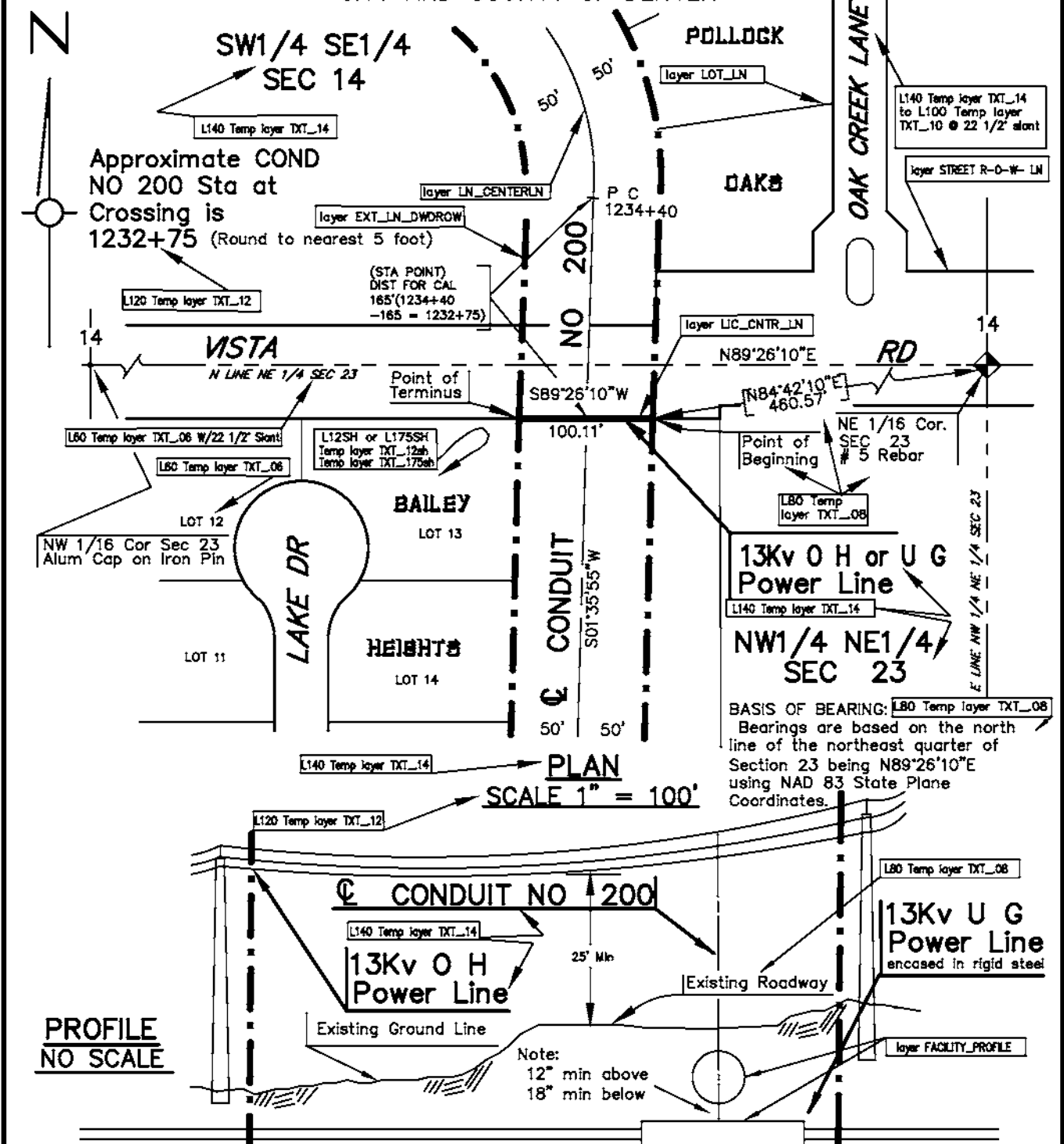
D.W.D. PROP. ADMIN. STD. 10222004

(SPECIMEN_D)

OVERHEAD CROSSING
DRAWING NOT TO SCALE

NW 1/4 SECTION 23, TOWNSHIP 5 SOUTH, RANGE 68 WEST 6th P M

----- CITY AND COUNTY OF DENVER -----






UNDERGROUND CROSSING
DRAWING NOT TO SCALE

Bearings are based on the west line of the southeast quarter Section 31 between the S1/4 Cor of Sec 31 and the Center of Sec 31 being N00°24'30"E using NAD 83 State Plane Coordinates.



D.W.D. PROPERTY MANAGEMENT STANDARDS. 10222004

CENTERLINE DESCRIPTION
DRAWING NOT TO SCALE

LEGEND  BOUNDARY D.W.D. PROPERTY  BNDRY EXISTING D.W.D. ESMT  EASEMENT GRANTED		DOCUMENT DATED SEC'Y FILE DOC. RIMS ITEM NO. CARD NO. DRN. ZYX PM. ——— S. APPD SHEET 70F 8 SHEETS		D DENVER WATER LEAVE THIS SPACE BLANK DATE: SEPTEMBER 1, 2004 SCALE: 1" = 100' CAD	
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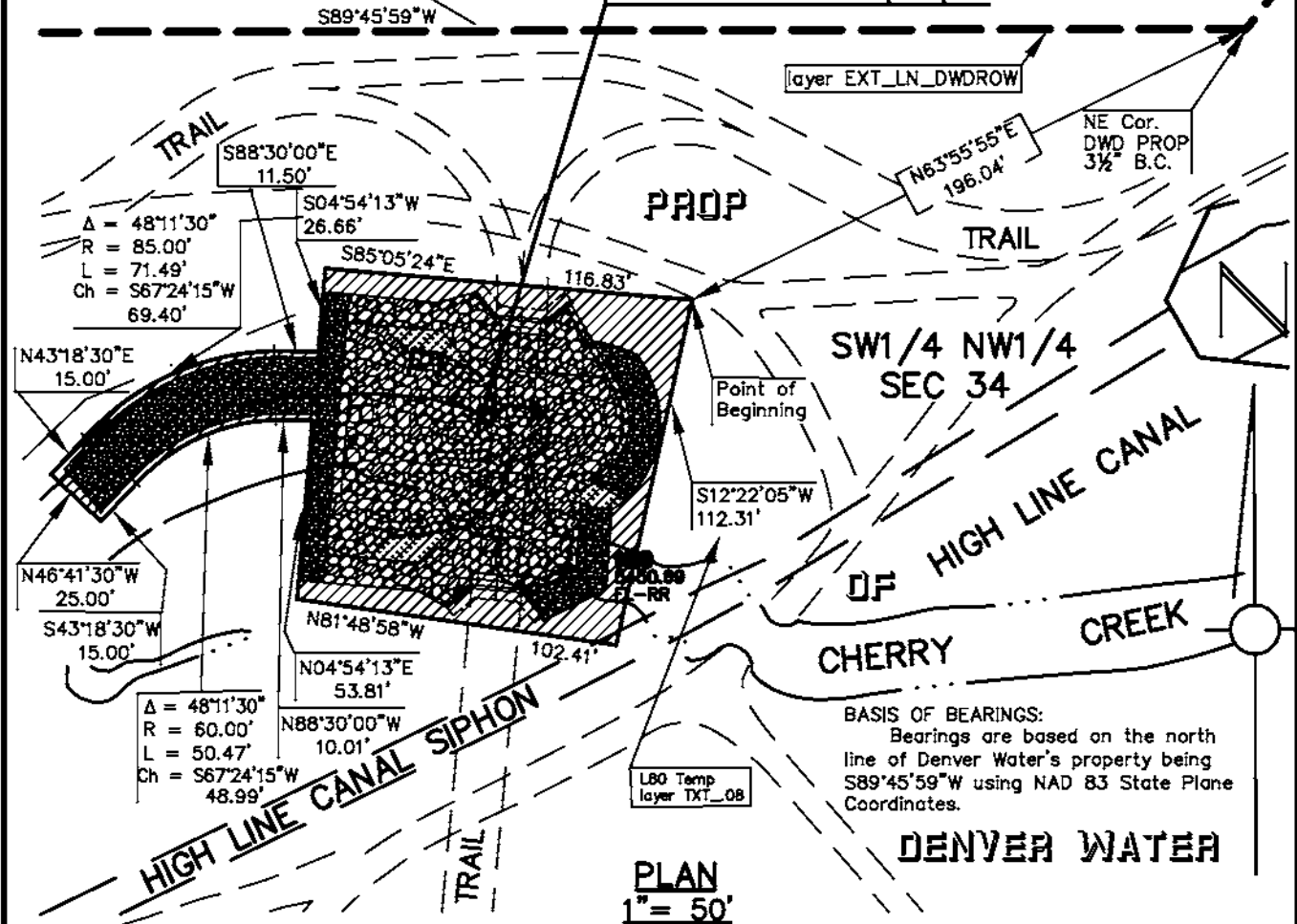
(CAD SPECIMEN_G)

SIMPLIFIED AREA
DRAWING NOT TO SCALE

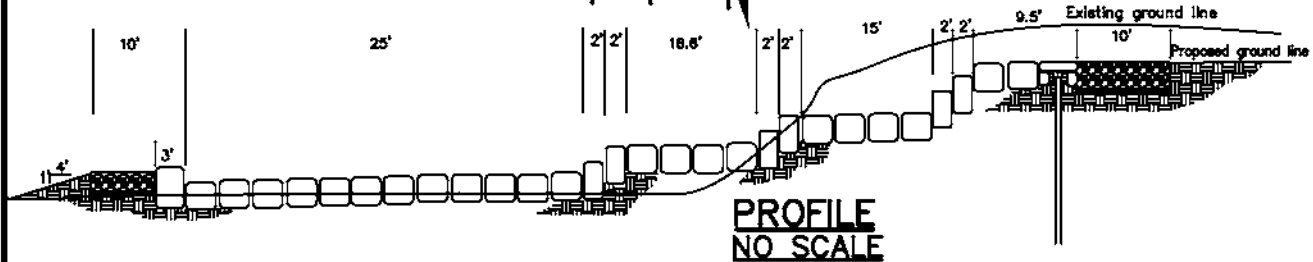
NW 1/4 SECTION 34, TOWNSHIP 4 SOUTH, RANGE 67 WEST 6th P M

ARAPAHOE COUNTY

Drop Structure No. 23
Embankment Riprap



Drop Structure No. 23
Embankment Riprap



PARCEL CONTAINS 12,835 SQ FT ±

LEGEND

- BOUNDARY D.W.D. PROPERTY
- LICENSE AREA GRANTED

DOCUMENT DATED
SEC'Y FILE DOC.

RIMS ITEM NO.
CARD NO.

DRN. ZYX PM. S.

APPD

SHEET 8 OF 8 SHEETS

DENVER WATER

LEAVE THIS SPACE BLANK

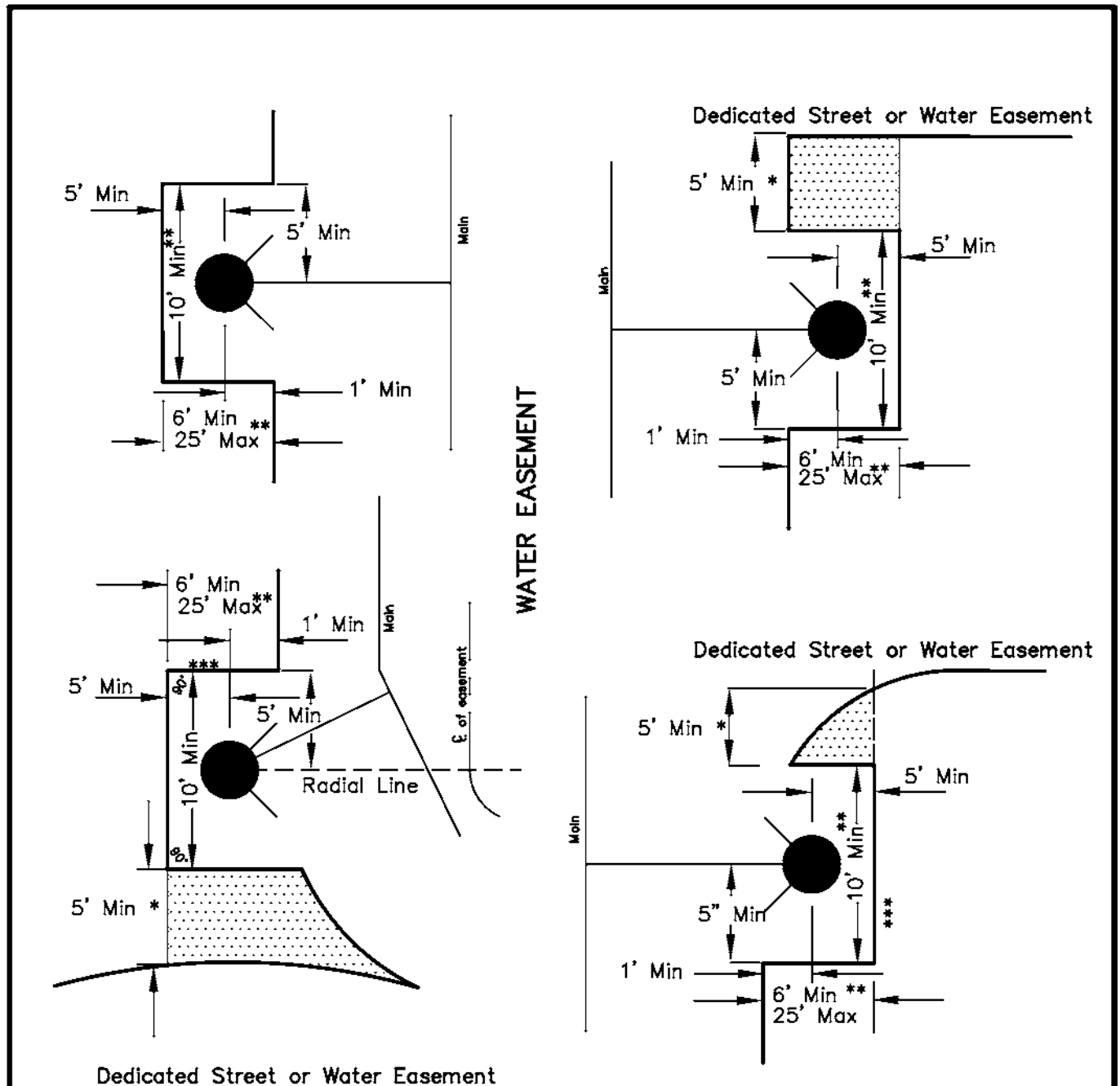
DATE: SEPTEMBER 1, 2004

SCALE:

CAD

(SPECIMEN_H)

FIRE HYDRANT EASEMENTS
DRAWING NOT TO SCALE



- * If this distance is less than 5 feet the shaded area must be added to the water easement.
- ** If the easement length is over 25 feet it must be a minimum of 30 feet wide.
- *** All water easement lines around any fire hydrant must be straight with the side easement lines perpendicular to or parallel with the radial line from the C of the main easement.

	DOCUMENT DATED	D DENVER WATER
	SEC'Y FILE DOC.	
	RIMS ITEM NO.	
	CARD NO.	
	DRN. ZYX PM. S.	
	APPD	DATE: SEPTEMBER 1, 2004
	SHEET 1 OF 1 SHEETS	SCALE: CAD

D.W.D. PROPERTY MANAGEMENT STANDARDS. 10222004

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 5 – System Design And Layout

5.01 General:

The purpose of this chapter is to provide information on the design and layout of water distribution systems acceptable to Denver Water. The following criteria shall apply equally to the City and County of Denver, Total Service Areas, and Distributor Contract Areas.

Denver Water has designed and built its system using conduits as the backbone for supplying all distribution systems. The distribution system then delivers water to the individual customer in sufficient volumes and without excessive headloss. The design and layout criteria in this chapter apply to distribution systems only. Design and layout criteria for conduits are covered in Chapter 10.

In some instances conduits supply transmission mains, which then deliver water to the individual customer. Chapter 9 deals with the design and layout criteria for transmission mains.

5.02 Quality Of The Distribution System:

The purpose of these Engineering Standards is to ensure that only proven high quality materials are installed using first class workmanship. Determination of the best materials and construction methods are based upon lowest life cycle costs, not upon lower initial costs. Sizing and layout of the system are parts of the total consideration of design, operation and maintenance of a water supply system that yields optimum quality service at the lowest total cost to the consumer.

5.03 Sizing Of Distribution Mains:

All mains shall be sized large enough to provide for domestic, irrigation, and fire protection flows to the area requesting service. The maximum acceptable headloss for 6, 8, and 12 inch mains is 2 feet per 1,000 feet of main for the maximum hour flow using a C value of 130. The 2 feet per 1,000 feet of main does not apply under fire flow conditions. Denver Water reserves the right to size mains to provide service for future needs.

All new mains shall be of one of the standard sizes set by Denver Water. Standard sizes are 6 inch, 8 inch, and 12 inch mains. Mains smaller than 6 inches may be used in some cul-de-sacs if approved by Denver Water.

The sizing of Distribution Mains follows a standardized grid based upon careful consideration and analysis of results of distribution system studies utilizing network

simulation. This grid requires a 12 inch main every half mile with alternating 6 inch and 8 inch mains in the streets within the quarter section and a 6 inch or 8 inch main in the street at approximately the 1/16 line to eliminate half mile runs in the system. See Sheet 9 of the [Standard Drawings](#) for a typical grid layout.

In residential areas the main shall be 8 inches in diameter. Six inch diameter pipe may be used where it completes a grid, but it is not to be used in blocks more than 600 feet in length unless approved by Denver Water. Four inch mains may be acceptable in cul-de-sacs serving only 6 taps or less.

In business and industrial areas an 8 inch main is used only where it completes a grid. Twelve inch mains are used for long runs not interconnected.

Planned building groups are treated the same as industrial or business areas because of the high fire risk, the large number of long single feeds and the minimal intersection of mains.

In adherence to the recommendations of the Insurance Services Offices, for economic reasons and as a fire service obligation, looping shall be done in conjunction with the main extension.

The present sizing of the grid system has the benefit of utilizing the system as an integral part of the overall transmission system in that water is distributed without excessive headloss. Denver Water shall analyze grid systems for developing areas to determine their adequacy. Parallel mains are not allowed.

5.04 Fire Protection Systems:

A. Fire Hydrants: The number and location of fire hydrants in a given area is determined by the appropriate fire protection bureau. Normal practice is to install fire hydrants on the northeast corner of the street intersections. If hydrants are to be installed at locations other than street intersections, they shall be located on lines, which are established by extending property lot side lines into the streets. See Sheet 7 of the [Standard Drawings](#).

Fire hydrant branch lines shall be set at right angles to street mains. The hydrant shall be set at the end of the branch line and shall face the branch line. No horizontal or vertical bends or reducers shall be used in fire hydrant branch lines unless specifically approved by Denver Water. Under no circumstances shall any size or manner of tap be made on a fire hydrant branch line.

A dead-end main shall have no more than one fire hydrant connected to it, except as specifically approved in writing by Denver Water or Distributor.

B. Firelines: Connections made to existing mains and run to the property line to provide water for fire protection systems are known as firelines and their sizes are determined by those persons responsible for protecting the structures served.

Firelines shall be installed at right angles to the Distribution Mains and shall run straight from the mains to the property lines. No horizontal or vertical bends shall be installed in these lines, except in the case of making a wet tap where the tap location conflicts with an existing pipe joint or where interference prohibits a straight line installation. Such horizontal or vertical bends shall be used only when

specifically approved by Denver Water.

C. Backflow Prevention: An approved backflow prevention assembly must be installed on all water service connections that supply a fire protection system. See [6.11](#)

5.05 Operating Pressures Within The Distribution System:

Pressures within the distribution system shall be a minimum of 40 psi during the maximum hour demand and a maximum of 110 psi static pressure in the main. The maximum pressure fluctuation at any location in the distribution system between maximum hour demand and minimum hour demand shall not exceed 30 psi.

5.06 Pressure Regulating Stations:

Pressure regulating valve (PRV) installations are used to control pressures within distribution systems. When main extension plans are submitted for review the need for a pressure regulating valve installation will be determined based on existing pressure zones and the existing distribution system layout. Within Denver and Total Service Areas, PRV setting(s) are to be included on plans with the following information: elevation, upstream and downstream hydraulic grade line and pressure, with Denver Water making all pressure settings and field adjustments. On plans submitted in Master Meter and Read and Bill areas, which require a PRV, Denver Water reserves the right to verify the settings. PRV(s) connected to Denver Water conduits shall be owned and maintained by Denver Water.

In certain situations, Denver Water shall require monitoring of the valve(s) via supervisory control and data acquisition (SCADA) equipment. The equipment used shall be of the manufacture and type specified or approved by Denver Water. See [5.12](#).

5.07 Storage Facilities:

A. Installation: Water storage facilities will be allowed for storing water from Denver Water's system where specifically authorized and approved by Denver Water.

B. Cleaning and Drainage: Storage facilities shall have built-in provisions for draining as well as access and provisions for cleaning including a suitable source of water. The cleaning and drainage facilities shall be subject to the approval of Denver Water.

C. Electronic Monitoring Equipment: Denver Water may require the installation of supervisory control and data acquisition (SCADA) equipment for storage facilities of the type specified by Denver Water. See [5.12](#).

5.08 Electric Pump Motors:

All motors shall be polyphase squirrel-cage rotor induction motors. Each motor shall be capable of delivering adequate starting and running torque sufficient to meet all the electrical, and operating conditions of the installation, and shall conform to [MS-24](#). Motor sizing shall not make use of the service factor. Each motor shall be rated for direct across-the-line, full voltage, starting. Each motor shall be controlled by a motor starter which

employs a method of starting consistent with the requirements of the electric power utility, the plant power system, and consideration of extended motor life and reliability and acceptable voltage drop during starting. Each starter shall be equipped with motor protective devices in the form of: overload relays; phase reversal, phase loss, and undervoltage relay trips; ground fault detection; motor winding and bearing overtemperature alarm and trip; and any other such functions as may be required by Denver Water for a particular installation.

All pump motor installations shall maintain an overall plant power factor between 0.9 and 1.0 lagging under normal operating load. If necessary, each motor shall be equipped with power factor correcting capacitors, as required, in order to meet this.

Each motor shall be designed and constructed to operate, without damage in reverse rotation at the maximum speed obtainable with the connected pump acting as a turbine under the conditions given by the approved hydraulic system design.

5.09 Pumping Facilities:

A. General: Pumping facilities will be allowed on mains or services supplying water from Denver Water's system only where specifically authorized by Denver Water. Denver Water shall prohibit the installation of pumping facilities where, in Denver Water's opinion, such installations would be injurious to the operation, or future operation, of Denver Water's system.

Material, equipment, and construction shall conform to applicable or specified codes and standards, and shall be approved by Denver Water.

B. General Design Criteria: Pump stations receiving water from Denver Water shall conform to the following requirements regardless of function or location:

1. Secured against unauthorized entry.
2. Located and in a manner, that will allow easy and safe access for maintenance and inspection.
3. Provide ventilation in the pump station designed to prevent the entry of small animals and insects.
4. Provide heating and cooling, to insure safe and efficient operation of all piping, pumping equipment, instrumentation, and alarms.
5. Size pumping capacity to provide fire demand; maximum day demand; maximum hour demand; or replenishment whichever is greater.
6. Provide means for measuring flow on pump discharge header(s).
7. Provide corrosion protection for underground steel and iron.
8. Provide local and remote electronic telemetry equipment of the type specified by Denver Water for monitoring discharge pressure and pump motor status. See [5.12](#).
9. Provide frost proof gravity line or sump pump for pump station drainage.
10. Provide means to prevent water from backing up into the pump station from other sources (e.g. check valve on drain line).

11. When economically feasible, standardize equipment to permit interchangeability with that of other equipment.
12. Special care shall be exercised in the selection of pumping units and associated components to prevent pressure surges and insure the suitability, flexibility, and adaptability of the units to the hydraulic conditions of the system from which water is taken and the system into which water is pumped.
13. The horsepower rating of each pump motor shall be such that the motor will carry continuously the maximum load that is possible to develop at any point on the pump curve without exceeding the motor nameplate rating and without using the service factor. The motor shall conform to the requirements of [6.46](#).
14. Provide that all pumps are located to receive positive suction head or meet the manufacturer's required net positive suction head.
15. Electrical design, equipment selection, and installation practices are subject to prior approval by Denver Water. Three copies of single-line drawings showing the power system, switchgear, protective devices, feeder panels and wiring, and motor controllers along with sizing, fault current, and protective device coordination calculations shall be submitted. The latest edition of the NEC, OSHA's "Design Safety Standards for Electrical Systems", and applicable ANSI/IEEE Standards shall set the minimum standards to which all design, equipment, and installation must conform. Denver Water may set higher standards if the requirements of safety or reliability require them.
16. Provide slow-closing regulating/check valves on all smaller pumps (0-2,000 gallons per minute) to minimize water hammer.
17. Provide ample clearances between equipment for operation and maintenance activities.
18. Provide electrical outlets and lighting on walls as needed in the pump room.
19. Provide certified manufacturer's pump performance curves.

C. Conditional Design Criteria: Depending on the function and the location of the pump station any or all the following criteria may be required by Denver Water:

1. Building architecture is to be aesthetically pleasing and compatible with the surrounding area.
2. Provide attractive, water conserving landscaping around pump station, and exterior and interior lighting.
3. Provide access and parking for vehicles on pump station site.
4. Provide fencing for securing area around pump station and transformers.
5. If applicable, provide space for future additions of pump(s) and piping.
6. Provide heating and cooling in pump station.

7. Provide a means to lift heavy equipment -- bridge crane or access for a boom crane.
8. Provide throttling control with appropriate discharge valves and controls.
9. Provide emergency power supply for telemetry, lights, drain sump pump, and any other necessary items.
10. Provide surge control.
11. Install guard valves on each side of pumping unit.
12. Systems shall be capable of supplying adequate fire protection during power outages.
13. Provide resistance temperature detectors in stator windings of pump motors for remote alarming upon overheating.
14. Provide spare pump for backup capability.
15. Provide pump and motor bearing high temperature sensors for remote alarming and lock out relays to shut down pump and motor (upon bearing overheating).
16. Provide aquastat over temperature shutdown switch on pump to protect from overheating. The aquastat shall not contain any mercury.
17. Depending on the motor size and electric power system, provide reduced voltage motor starters.
18. Provide dual transformers cross connected with tie breaker and separately switched for isolation.
19. Provide remote control for all pumps, gas engines, and filling valves (start - stop - position discharge valve).
20. Provide local and remote instrumentation for monitoring the following:
 - a. Discharge valve positions
 - b. Discharge header pressure and flow
 - c. Reservoir level (if applicable)
 - d. Upstream pressure (if applicable)
 - e. Suction header pressure (if applicable)
 - f. Pump status (on-off)
 - g. Gas engine stand-by generator status (on-off)
 - h. Total kilowatt demand (station)
21. Provide sensors and alarms to detect the following remote and local):
 - a. Water on the floor
 - b. Bearing high temperature for each pumping unit bearing
 - c. Motor windings high temperature for each pumping unit
 - d. Pump building door intrusion
 - e. High and low room temperature

- f. Electrical ground fault
- g. Low accumulator pressure (if applicable)
- h. Power failure
- i. High and low reservoir level (if applicable)
- j. Fire and/or smoke

5.10 Layout Of The Distribution System:

A. General: Mains shall be installed in dedicated public streets of the width defined below and of such grade, alignment, curvature, and other characteristics as to permit them to be laid and maintained in the normal and usual manner. When Denver Water determines it is not feasible for an installation to be made in a dedicated street, the installation shall be made in a Denver Water or Distributor easement.

The conditions under which such an exception will be allowed will be determined for each individual case, and only easements which conform to the terms of Denver Water's standard easement form and these Engineering Standards will be accepted. The easement requirements defined herein must be complied with prior to acceptance of any existing system for Total Service.

B. Alignment: Main alignment shall be parallel with dedicated right-of-way or easement lines. Normal practice is to lay the main on the north or east side of the street 5 feet or 10 feet from the centerline of the street. In all cases where main alignment is within an established public or private roadway, the main shall be installed between the limits of curb and gutter pan, roadside drainage ways, or other such roadway limits except as specifically authorized by Denver Water. Also, there shall be a minimum of 10 feet from any edge of the dedicated right-of-way or easement to the centerline of the main, except as otherwise approved by Denver Water.

C. Easement Width Requirements:

1. Dedicated Street: The cross section of a dedicated public roadway shall meet the minimum requirements of a 28 foot surfaced roadway flow line to flow line with an additional 2-1/2 feet on each side for the installation of fire hydrants, behind sidewalks and curbs, as shown on Sheet 3 of the [Standard Drawings](#).
2. Public dedicated roadways designed with islands at entrances to developments must comply with the following criteria:

The island must be located in the middle of the roadway (approximately) and/or in such a manner as to allow for an unencumbered minimum width of 20 feet from back of curb of island to back of curb or roadway. The water line must be installed on the side of the island that is at least 20 feet wide as described above and preferably have no other utilities installed within that 20 foot wide area.
3. Private Roadways: The easement shall have a minimum width of 30 feet and Denver Water or the Distributor shall have exclusive use of 20 feet

thereof, except for right angle utility crossings. The cross section of a private roadway must have as a minimum:

a. Twenty-six feet of surfaced roadway with a 4 foot wide attached sidewalk, making a total of 30 feet of surfaced area from back of curb to back of sidewalk as shown on Sheet 4 of the [Standard Drawings](#),

OR

b. Twenty-nine feet of surfaced roadway with 6 inch wide concrete curbs, making a total of 30 feet of surfaced area from back of curb to back of curb, as shown on Sheet 4 of the [Standard Drawings](#),

OR

c. Thirty-feet of surfaced roadway with permanent delineation on both sides, the type, material and location of which is pre-approved by the Property Management Section as a part of the plan review process, and where neither cross section on Sheet 4 of the [Standard Drawings](#) is practical.

d. Roadways designed with islands at entrances to developments shall have easements that extend across the entire roadway including the island, with the island located (approximately) in the middle. The water line shall be installed on a side of the island that is at least 20feet wide from back of curb to back of curb and will have no other utilities installed therein. All other utilities shall be confined to the opposite side of the island.

An easement conforming to the terms of Denver Water's Standard PUD/ PBG form of easement agreement shall be granted to Denver Water.

3. Undeveloped Areas: The minimum width easement in which distribution mains will be installed is a 30 foot exclusive or a 50 foot non-exclusive easement.

D. Alleys: New installation or replacement of a water main in an alley is strictly prohibited.

E. Fire Hydrants: All fire hydrants shall be installed within dedicated streets or in the easements as defined above. When Denver Water determines it is not possible or feasible for a hydrant to be installed in this manner, it shall be installed in an easement contiguous to said street. The fire hydrant easement shall have a minimum width of 10 feet, if the length is 25 feet or less. Fire hydrant easements shall have a minimum width of 30 feet when the length of the easement is more than 25 feet. The easement shall extend a minimum of 5 feet beyond the center of the hydrant. See Sheet 7 of the [Standard Drawings](#).

Fire hydrants shall be installed only at locations authorized by the appropriate fire protection bureau.

5.11 Line Valves:

Line valves are required approximately every 600 feet in all distribution systems receiving water from Denver Water. Where blocks exceed 600 feet in length, or if 2 or more

hydrants are connected to the same main, additional line valves are required in the middle of the block. Street intersections carrying heavy traffic, or containing major water distribution mains in both directions, require 4 valves, one on each extended property line. For a succession of short blocks perpendicular to the direction of major feed and without residential services between, several intersections may have the valve omitted in that direction but should retain the 600 feet interval requirement. A line valve is required between fire hydrants in commercial, residential and industrial areas.

5.12 Connections To Conduits:

All connections to conduits owned or controlled by Denver Water shall be installed by Denver Water unless otherwise authorized by Denver Water. Denver Water shall provide and install, at cost, all fabricated pipe, tapping saddles, valves, etc., that are necessary to construct the connection.

5.13 Supervisory Control And Data Acquisition (Scada):

Supervisory Control and Data Acquisition (SCADA) installed for use by Denver Water to monitor, control and coordinate the operations of the water system, or the operations between a Distributor's water system and Denver Water's system, shall be designed, installed, and maintained according to the following standards and practices:

A. General:

1. Equipment and instruments SCADA shall be in accordance with [MS-29](#) subject to approval by Denver Water.
2. Construction and installation of this equipment shall be in accordance with design drawings and specifications submitted to and approved by Denver Water prior to commencement of construction of the system. Designs and specifications shall be prepared using ISA industry standard electrical/ electronic and instrumentation symbols and drafting practices. Any changes in design or equipment specifications on approved plans shall require reapproval by Denver Water before the changes are implemented in the system. Only drawings approved by Denver Water's Process Control Section shall be used for construction and installation of the SCADA system.

- a. For systems requiring 15 I/O points or less (in any combination of analog and digital points) and containing no more than one closed loop control loop, the following documentation is required.

Control viewpoint containing an overview of how the system is to operate including: a listing of digital and analog I/O points, control loop descriptions, set points, normal operating ranges, alarm points operating sequence and operator interface information. The control viewpoint is used for check-out, start-up, system revisions and maintenance.

Equipment list detailing the following for all equipment and instruments: equipment tags to be used throughout drawings (ISA standards preferred), manufacturer and model number, and a concise description of the manufacturer's specifications as they apply to the requirements of the process. Manufacturer's cut-sheets and literature shall accompany this list. The equipment list is used by Denver Water's Process Control

Section to review equipment submitted for approval, and as a cross-reference guide for the drawing package.

Instrumentation and Control P&ID Typical showing the instruments and associated equipment interconnections in block form using ISA standards. The nomenclature established on the equipment list should be used here. The flow of signals shall move from left to right across the drawings. Normal operating points, signal levels, frequencies, and instrument adjustments shall be shown. P&ID's are intended to be used for design and installation. See Sheet 68 of the [Standard Drawings](#).

Instrumentation and Control Cabinet Layout Typical including layouts for all operating stations, push-button stations, terminal boxes, control equipment enclosures, etc., to clearly show the location of all panel-mounted telemetry/control system components. Panel layout drawings are intended to be used for fabrication, installation and maintenance. See Sheet 66 of the [Standard Drawings](#).

Instrumentation and Control Detail and Schedules Typical including a parts/instrument material schedule for all equipment located in enclosure, name plate schedule, panel cut-out details, etc. These drawings are also intended for use in fabrication, installation and maintenance. See Sheet 67 of the [Standard Drawings](#).

Instrumentation and Control Ladder Diagram Typical showing all necessary electrical connections to equipment in schematic form and ladder logic, if applicable. Any set points or other information pertinent to the installation of the system shall be included. All information regarding power requirements shall be shown, including: main power feed capacity, voltage and origin; and transformer and power supply available load and operating voltage

Wiring details such as wire numbers, colors and sizes, along with terminal numbers/names for all terminals whether off a terminal strip or instrument terminal, is required. Concise nomenclature for all equipment functions is required. Schematics are intended for use in fabrication, installation and maintenance. See Sheet 64 of the [Standard Drawings](#).

Software documentation in the form of a hard copy printout and a 3-1/2 inch diskette copy of the completed program is required, if applicable.

b. For systems requiring more than 15 I/O points or containing more than one closed loop control loop, the following drawings are required along with those outlined above:

Instrumentation and Control Site Diagram Typical showing the relative locations of all panels and field mounted instruments in plan view and using the designated nomenclature from the equipment list. Component layouts are intended to aid in installation and maintenance. See Sheet 69 of the [Standard Drawings](#).

Instrumentation and Control Wiring Diagram Typical showing the actual wiring interconnections from terminal in graphical form. This drawing is used for installation and check-out and is not expected to be maintained

after start-up. See Sheet 65 of the [Standard Drawings](#).

3. Equipment and wiring shall be installed and mounted in such a manner as to provide easy access and protection from mechanical and thermal damage as well as condensation or other forms of moisture. NEMA Standards shall be applied for all enclosures. Wiring connections shall be done in a neat workmanlike manner, and shall be laced or bundled using cable ties, or enclosed in PVC wiring duct. In-line splices or wire nuts shall not be allowed. Each end of a wire shall be identified by a permanent wire marker that corresponds to the wire identification used on the final as-built detailed drawings. No more than 2 wires shall be permitted on each terminal block screw. A minimum of 10% of the terminal block positions or din rail space shall be provided as spare for future changes or additions. Twisted, shielded pairs shall be used for all instrumentation wiring for analog devices (4-20mA signals, etc.). Terminations of analog signal wires shall be made by Denver Water's Process Control Section unless otherwise specified. All low voltage DC wires shall have separate conduit runs from 120VAC and higher voltage wires. Each separate instrument or device in the system shall have affixed to it a permanent identification label corresponding to the final as-built detailed drawings. The latest editions of NEC and OSHA's "Design Safety Standards for Electrical Systems" shall set the minimum standards of which all design, equipment, and installation must conform. Denver Water may designate additional standards to insure safety, reliability and compatibility with existing systems. Wire coloring code shall adhere to the following:

120VAC power - Black

120VAC neutral - White

GROUND - Green

12, 24, 48VDC power - Red

12, 24, 48VDC common - Black w/red stripe

Digital outputs (control) open, start - Red

close, stop - Blue

Digital inputs (status, alarms) - Yellow

Telephone wiring (communication) - Orange

4. A site inspection by Denver Water's Process Control Section is required prior to installation of telemetry/control equipment. Contractor shall notify Denver Water's Process Control Section at least one week in advance of commencement of the installation to arrange an inspection date. SCADA system operation shall agree with the control viewpoint previously approved. All SCADA systems and equipment shall be subject to inspection and operational acceptance tests by Denver Water's Process Control Section before being placed into service. All wires shall be inspected for continuity and termination, and all instruments shall be tested to ensure proper operation. Contractor shall notify Denver Water's Process Control Section one week in advance of the completion of installation to arrange a final inspection date.

5. Pressure transmitters shall be installed in the center of the conduit and "teed" with a pressure sign gauge for local pressure readings. All flow measurements shall be a combination of 2 differential pressure transmitters; a high range transmitter calibrated for the maximum design flow rate and a low range transmitter calibrated to 25% of the maximum design flow rate. Level transmitters (including pressure transmitters used for level measurement) shall be installed on a separate sensing line. No other instrumentation shall be permitted on this sensing line.
6. Control systems, which incorporate sources of motive power, shall utilize either electrical or hydraulic (oil) fluid power actuator mechanisms. Use of compressed air as a prime motive power source or compressed air powered actuators are not allowed. Use of air over oil accumulators as a source of reserve hydraulic power is allowed. These motive power systems shall be included in the SCADA system drawings submitted for approval. Standard Electrical Industry and National Fluid Power Association drafting symbols and practices shall be used.
7. Three copies of all manufacturer's instruction manuals, parts lists, and service information, as well as 3 sets of the as-built drawings, control viewpoint and equipment lists shall be provided to Denver Water within 30 days after the completion of start-up and satisfactory performance of the equipment has been achieved, as dictated by Denver Water.

B. Additional Requirements for Coordinating Operations Between a Distributor's Facility and Denver Water:

1. The required standard for these SCADA systems shall be no higher than those used for telemetry installations made by Denver Water and shall adhere to the specifications outlined in the above [5.13 A](#). The control viewpoint shall be used as the design standard and written in conjunction with the Distributor and Denver Water's Process Control Section.
2. SCADA system power shall be provided by the Distributor including all conduit and wires from power source to telemetry and control panel and/or field devices. All other labor related to the design, construction and maintenance shall be provided by Denver Water and paid for by the Distributor, unless otherwise requested by the Distributor and approved by Denver Water.
3. The minimum I/O points required for treated water distribution are:
 - Up-stream pressure (analog signal)
 - Down-stream pressure (analog signal)
 - Valve position (analog signal)
 - Remote/local control selector switch position (digital signal)
 - Local open/close valve selector switch (hardwired digital signal)
 - Valve open command (digital signal)
 - Valve close command (digital signal)
 - Water on Floor (WOF) alarm (digital signal)
 - Vault intrusion alarm (digital signal) - optional

4. All instruments and equipment shall be of a manufacturer and model specified by [MS-29](#), unless otherwise approved by Denver Water's Process Control Section. Any telemetry and control equipment not specified in [MS-29](#) must be approved by Denver Water's Process Control Section before purchase by the Distributor.
5. Denver Water shall specify, order and pay for the monthly service of any telephone lines required for the system. The Distributor shall pay for the initial connection fee.
6. Within 30 days after completion of the system, the Distributor shall provide Denver Water with all keys necessary to gain 24 hour access to the telemetry system located at the Distributor's facility.
7. Any additions, changes, or other modifications to the SCADA system after it has been placed into service must be approved by Denver Water prior to implementation. The required work shall be done by Denver Water unless otherwise requested by the Distributor and approved by Denver Water's Process Control Section. Distributor shall provide as-built drawings and documentation within 30 days after completion of the approved work to Denver Water's Process Control Section.

5.14 Interconnects With Other Water Systems:

Interconnections between Denver Water's treated water system and another Denver Water approved system shall only be allowed in accordance with [Section I0.02](#) of the Board's Operating Rules.

A. Semi-Permanent Facilities: Where the location of an interconnection can be identified and included in a written agreement between Denver Water and the other party to the interconnection, such facilities shall be constructed in accordance with Sheet 78 and 79 of the [Standard Drawings](#) for a dual feed connection and Sheet 80 for a single feed connection. Such facilities shall normally consist of one or more 6 inch lines, each consisting of meter, check valve, and associated piping as detailed in the drawing. No bypass line shall be included. All other provisions of these Engineering Standards shall apply.

B. Temporary Hose Connections: Where emergency conditions require the use of temporary connections between fire hydrants in order to serve Denver water into another system, such installation shall conform to Sheet 81 of the [Standard Drawings](#). Such conditions shall always include an appropriate meter as described in the drawing.

Activation of interconnections shall be in accordance with Denver Water's standard procedures.

5.15 Flow Measurement:

The Board may require pitot installations for future flow measurement. If so, a corporation stop shall be installed in order to be converted to a pitot installation at a later date as shown on Sheet 82 of the [Standard Drawings](#).

Engineering Standards - Chapter 5:
Revised 07-04, Previous Revision 05-02
End

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 6 – Materials

6.01 Materials And Testing:

Detailed technical specifications for purchase or approval of materials are included in the Materials Specifications of these Standards. All materials shall conform to the Materials Specifications and to all limitations on acceptable makes and styles.

Materials furnished shall be new and undamaged. Everything necessary to complete installations in accordance with the Engineering Standards of Denver Water shall be furnished and installed whether shown on approved drawings or not; and installations shall be completed as fully operable, functioning parts of the Denver water system.

Where mains are extended by Applicants, it shall be their responsibility to provide all materials necessary for the installation. No materials will be supplied to the Applicant by Denver Water.

Acceptance of materials, or the waiving of inspection thereof, shall in no way relieve the Applicant of the responsibility for furnishing materials meeting the requirements of the Materials Specifications.

New water industry products or materials will be tested if it is the opinion of the Engineer that the product or material has some merit. Denver Water will establish the criteria for testing and evaluating the product. Denver Water reserves the right to accept or reject any product or material regardless of the test results. See [Appendix A, Procedure For Evaluation Of Materials](#).

6.02 Size Of Mains:

The size of mains shall be in accordance with [5](#). Standard acceptable nominal diameters of distribution mains are 4, 6, 8, and 12 inches. Standard acceptable nominal diameters of transmission mains are 16 and 20 inches. Standard acceptable nominal diameters for conduits are 24 inches and larger.

6.03 Pipe Classes:

Denver Water has established minimum design safety factors for system piping considering working pressures of 150 psi concurrent with water hammer surge pressure of 120 psi for 4, 6, and 8 inch pipe, 110 psi for 12 inch pipe and 70 psi for 16 inch and larger pipe.

Based upon these considerations, the following minimum AWWA Standard pressure

classes for acceptable types of pipe are required:

- | | | |
|-------------------|---|---|
| Ductile Iron (DI) | - | Special Class 50 (6, 8, 12 & 16 inch)
Special Class 51 (4, 20 & 24 inch) |
| Plastic (PVC) | - | Class 150 (6, 8 & 12 inch)
Class 200 (4 inch) |

6.04 Selection Of Pipe:

In general, selection of type of pipe shall be left to the discretion of the Professional Engineer in charge of design. However, Denver Water reserves the right to deny use of certain types of materials in specific circumstances.

Where joint restraint is required, the designer shall select a pipe together with an approved system of restraint. It should be noted that installation of any metallic pipe, rods, clamps, etc. in corrosive soil areas will require corrosion protection systems.

Installation of mains through tunneled crossings such as at railroads, highways, canals, etc., will require the selection of metallic pipe with approved joint restraint systems. Bridge hangings will also require selection of metallic pipe with joint restraint.

Installation of mains at airports, through hazardous areas, at depths greater than 10 feet and in the roadways of State and Federal highways may require the selection of pressure classes in excess of the minimum stated in [6.03](#). Special comprehensive studies of applicable laws, regulations, and detailed engineering calculations shall be submitted for review by Denver Water in these instances.

Whenever the installation of metallic pipe is contemplated, a soil resistivity survey of the construction area shall be performed. The survey data and calculations, together with the service history of other existing pipe in the area, shall be submitted to Denver Water. Resistivity surveys shall utilize the Wenner four-pin method. Denver Water will provide the resistivity surveys, free of charge, on request. This service will also be provided when installing non-metallic pipe in order to determine if protection is needed for metallic fittings and appurtenances.

When water mains are to be constructed in soils that have a resistivity of less than 1,000 ohm-centimeters, or where stray current corrosion is expected to be severe, an approved non-metallic pipe system shall be selected. When water mains are to be constructed in soils that have a resistivity of more than 1,000 ohm-centimeters, either metallic or non-metallic pipe material may be selected. All metallic pipe, joint restraint, fittings, tie rods and appurtenances, regardless of soil resistivity, shall be protected against corrosion by polyethylene wrap in accordance with [8.24](#).

* See [10.06](#) for Special Class 50 alternate for 24 inch.

6.05 Pipe Fittings:

A. Joints: Joints and fittings shall conform to the applicable AWWA Standards, and shall bear at least the pressure rating of the straight pipe involved. Acceptable types for straight lengths of pipe are push-on and mechanical joint. Mechanical joints for straight lengths of pipe will be allowed only under specific situations receiving approval of Denver Water.

Within the City and County of Denver and Total Service Contract Areas, all fittings shall be furnished with mechanical joint ends and shall conform to [MS-3](#). Private pipe extensions may use mechanical joint or push-on joint fittings and otherwise shall conform to [MS-3](#). Exception: Fire hydrant tees shall be mechanical joint ends. Flanged joints are permitted where specified in the Materials Specifications. The use of wyes is strictly prohibited.

B. Closure Fittings: Bolted Sleeve Type Couplings in accordance with AWWA C219 shall be of a gasketed, sleeve-type, with diameter to properly fit the pipe. Tolerance on pipe and coupling, together with proper bolt and gasket arrangements, shall be sufficient to insure permanent watertight joints under all conditions. Couplings shall be sufficiently wide, so that each type of pipe joined will have as much pipe end inserted in the couplings as is provided by the standard push on or mechanical joint for the pipe size and type involved.

The following table contains the minimum center sleeve dimensions for bolted sleeve type couplings:

Pipe Diameter (Inches)	Center Sleeve Thickness (Inches)	Center Sleeve Width (Inches)
4	0.250	5
6	0.250	5
8	0.250	5
12	0.375	7
16	0.375	7
20	0.375	7
24	0.375	7

Cast or ductile iron sleeves shall have mechanical joints of the proper size and tolerance to assure a water tight fit.

"Long bell" closure pieces shall be of at least equal strength to the straight pipe being joined and shall contain push on joints of the proper tolerance to insure watertight connections.

"Compression" fittings for small diameter pipe (less than 3 inch diameter) may be utilized for connection or repair only with approval of Denver Water.

Where pipes of different types are connected together, or where pipe is connected to fittings or valves of different materials, great care shall be taken to insure that the proper ring, insulating gasket, or adapter is selected.

C. Miscellaneous Pipe Fittings: Flanged adapters, plugs, end caps, bulkheads, cut-in sleeves, anchor couplings, repair fittings, and other appurtenances shall be used where appropriate throughout the system, subject to the approval of Denver Water. Denver Water does not intend to limit unreasonably, the installation of any type of fitting, joint, or proprietary device, however, the installation of any such fitting, not specifically approved by these Standards, is subject to the approval of

Denver Water. Written request for approval of deviating items shall be made in advance through Denver Water.

D. Clamps, Rods and Joint Restraint Devices: Harnessing of joints may be accomplished either by use of the clamp and rod system shown on Sheets 21 through 26 of the [Standard Drawings](#), or by use of one of the mechanical joint restraint systems as shown on Sheet 27 or 28 of the [Standard Drawings](#), and specified in [MS-27](#), or by use of one of the several proprietary joint restraint systems supplied by pipe manufacturers. The proprietary systems will require approval of Denver Water prior to use. Regardless of the system used, restrained lengths of pipe for various fittings, where harnessing is utilized or required, shall be at least equal to the lengths shown on Sheet 21 of the [Standard Drawings](#). Details and materials of clamps, rods and nuts, washers, rod couplings, and flange lugs used by Denver Water are shown on the Standard Drawings.

Where joint restraint is required on PVC pipe, the designer may use a joint restraint system of the type supplied by pipe manufacturers and approved by Denver Water or switch to a metallic pipe and use rods and clamps. The use of rods and clamps on PVC pipe is not allowed unless specific approval is granted by Denver Water.

6.06 Line Valves:

Line valves shall be gate valves conforming to [MS-4](#) or Resilient Seat Gate Valves, as specified in [MS-4A](#). The valves shall be of the same size as the main. Valves shall open to the right (clockwise). Valves with operators which open to the left (counterclockwise) shall not be used, unless required by or approval is obtained from Denver Water.

6.07 Pressure Regulating Valves:

A pressure regulating valve (PRV) is used for keeping downstream pressure at a uniform pressure less than that in the upstream main.

Pressure regulating valves shall conform to [MS-9](#). They shall be sized so that the velocity through the valve at maximum demand does not exceed 25 feet per second. If a wide range of flow rates is anticipated, more than one valve may be required. Care shall be taken to ensure adequate pressure differential across the valve under all ranges of flow to accomplish hydraulic throttling. When pressure differentials greater than 45 psi are expected, or when the downstream pressure will be low relative to the differential, special valve materials or a special valve design may be required.

Pressure regulating valves shall be properly supported, and shall have an adequate clearance above and below the valve to facilitate servicing. A manual bypass is required for all single valve installations. Telemetering of data may be required. Each PRV shall have a gate valve on each side for isolation. General arrangement shall be as shown on Sheets 43 through 46 of the [Standard Drawings](#).

6.08 Tapping Valves And Sleeves:

A tapping valve and sleeve are used together to tap an existing main that is in service and under pressure, without interrupting service. A tapping valve does not replace a

property line valve, which shall be required in addition to the tapping valve. A property line valve may not be required if a main's out-distance is 15 feet or less.

Connections 2 inches and smaller to mains shall be by a corporation stop of the same size as the service line.

Connections larger than 2 inches made to mains shall be either by an existing tee, by cutting a tee into a dewatered line if permitted by Denver Water, or by use of a tapping valve and a tapping sleeve. Whichever method is used, care shall be exercised to select sleeves and gaskets which are properly sized to fit the type and class of pipe to be tapped. Where tapping sleeves larger than 2 inches are used, a thrust block shall be formed and placed behind the tapping valve to prevent possible damage to the main from pressure shocks, which develop as valves are first opened. Tapping sleeves shall conform to [MS-8](#). Thrust blocks shall conform to Sheet 19 of the [Standard Drawings](#).

6.09 Check Valves:

A check valve permits flow in one direction only, closing when the flow stops so that no reversal can occur. Check valves shall conform to [MS-6](#). They shall be used where shown in typical meter installation. They are otherwise prohibited unless specifically approved by Denver Water. Check valves shall be located in concrete manholes of the same specifications as required for PRV manhole installations as shown on Sheets 43 through 46 of the [Standard Drawings](#).

6.10 Stop And Waste Valves:

All service lines shall have a stop and waste valve on the service line inside the residence near the location where the service line enters the residence. The stop and waste valve shall have a drain plug located on the valve body such that, when the valve is shut off, the drain plug can be removed and all water above the valve drained out. Stop and waste valves shall be approved by Denver Water. See Sheets 48 through 52 of the [Standard Drawings](#) for typical locations. Stop and waste valves shall conform to [MS-21](#).

6.11 Control Of Backflow And Cross Connection:

A. Cross Connection Control:

1. Denver Water is responsible for the protection of its public water system from contamination or pollution due to the backflow of contaminants or pollutants through the water service connection. The purpose of this program is to:
 - a. Protect the public water supply of Denver Water from the possibility of contamination or pollution by containing within the customer's internal distribution system(s) or the consumer's private water system(s) such contaminants or pollutants which could backflow into Denver Water's water system; and
 - b. Eliminate or control existing cross connections, actual or potential, between the consumer's in-plant potable water system(s) and non-potable water system(s), plumbing fixtures and industrial piping systems; and

- c. Provide for the maintenance of the Continuing Program of Cross Connection Control which will systematically and effectively prevent the contamination or pollution of potable water supplied by Denver Water.

B. Requirements for Backflow Prevention:

1. The water system will be considered as made up of two parts, Denver Water's system and the consumer's.
 - a. Denver Water's system consists of the source facilities and the distribution system, and includes all those facilities of the water system under complete control of Denver Water up to the point where the consumer's system begins.
 - b. The consumer's system includes those parts of the facilities beyond the termination of Denver Water distribution system and are no longer under Denver Water's control.
2. An approved backflow prevention device will also be installed on each service line within a consumer's water system, immediately following the meter, and in all cases, before the first branch line leading off the service line wherever the following conditions exist:
 - a. In the case of a premise with an auxiliary water supply which is not or may not be of safe bacteriological or chemical quality and which is not acceptable as an additional source by Denver Water, Denver Water's water system will be protected against backflow from the premises by installing an approved backflow prevention device in the service line appropriate to the degree of hazard found within the consumer's premises.
 - b. In the case of premises on which any industrial fluids or any other objectionable substance is handled in such a fashion as to create an actual or potential hazard to Denver Water's water system, Denver Water's system will be protected against backflow from the premises by installing an approved backflow prevention device in the service line appropriate to the degree of hazard found within the consumer's premises. This will include the handling of process waters originating from Denver Water's system, which have been subject to deterioration in quality.
 - c. In the case of premises having internal cross connections that cannot be permanently corrected and controlled, or having intricate plumbing and piping arrangements or where entry to all portions of the premises is not readily accessible for inspection purposes, making it impractical or impossible to ascertain whether or not dangerous cross connections exist, Denver Water's water system will be protected against backflow from the premises by installing a backflow prevention device in the service line.
 - d. In the case of premises where there is a fire protection system, an approved backflow prevention assembly must be installed on all water service connections. These would include such systems as residential,

commercial industrial or institutional facilities serving any combination of fire hydrants, potable water and fire protection systems. The type of device required will depend upon the degree of hazard as determined by the Cross Connection Control Manual of the Colorado Department of Public Health and Environment.

3. The type of protective device required will depend upon the degree of hazard, as follows:

- a. In the case of any premises where there is an auxiliary water supply, Denver Water's water system must be protected by an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly.
- b. In the case of any premises where there is water or a substance that would be objectionable, but not hazardous to health, Denver Water's water system must be protected by an approved double check valve assembly or an approved reduced pressure backflow prevention assembly.
- c. In the case of any premises where there is any material dangerous to health, which is handled in such a fashion as to create an actual or potential hazard to Denver Water's water system, Denver Water's water system must be protected by an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly. Examples of premises where these conditions exist include, but are not limited to, sewage treatment plants, sewage pumping stations, chemical manufacturing plants, hospitals, mortuaries and metal plating facilities.
- d. In the case of any premises where there are uncontrolled connections, either actual or potential, Denver Water's water system must be protected by an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly at the service connection.
- e. In the case of any premises where, because of security requirements or prohibitions or restrictions, it is impossible or impractical to make a complete in-plant cross connection survey, Denver Water's water system must be protected against backflow from the premises by an approved air-gap separation or an approved reduced pressure principle backflow prevention assembly on each service line to the premises.

4. Any backflow prevention device required will be a model and size designated by Denver Water and approved by the Colorado Department of Public Health and Environment. The term approved backflow prevention assembly will mean a device that has been manufactured in full conformance with AWWA C511 and, have met completely the laboratory and field performance specifications of the Foundation for Cross Connection Control and Hydraulic Research (FCCC&HR) of the University of Southern California established by: Specifications of Backflow Prevention 69, current edition. AWWA and FCCC&HR standards and specifications are adopted by Denver Water. Final approval of backflow prevention devices will be evidenced by a Certificate of Approval issued by an approved testing

laboratory certifying full compliance with said AWWA standards and FCCC&HR specifications. The following testing laboratory has been qualified by Denver Water and the Colorado Department of Public Health and Environment and accepted by Denver Water to test and certify backflow prevention devices:

Foundation for Cross Connection Control and Hydraulic Research
University of Southern California
University Park
Los Angeles, California 90007

5. It is the responsibility of the consumer at any premises where backflow prevention devices are installed to have certified inspections and operational tests made at least once per year. In those instances where the hazard is high enough, it may require inspections at more frequent intervals. These inspections and tests will be at the expense of the consumer and will be performed by a certified tester approved by Denver Water and/or the Colorado Department of Public Health and Environment. The consumer will notify Denver Water in advance when the tests are to be undertaken so that Denver Water's representative may witness the test if so desired. These devices will be repaired, overhauled or replaced at the expense of the consumer whenever said devices are found to be defective. Records of such tests, repairs and overhaul will be kept by the consumer, and a copy of such records will be furnished to Denver Water.

6. Presently installed backflow prevention devices which do not meet the requirements of this section but were approved devices for the purposes described herein at the time of installation and which have been properly maintained, will, except for the inspection and maintenance requirements under subsection G., be excluded from the requirements of these rules so long as Denver Water is assured that they will satisfactorily protect Denver Water's system. Whenever the existing device is moved from its present location or requires more than minimum maintenance or constitutes a hazard to health, the unit shall be replaced by an approved backflow prevention device meeting the requirements of Denver Water.

7. Denver Water shall review and approve the proposed backflow prevention device installation for all applications. Consultation with Denver Water Backflow Prevention Section may be required prior to plan submittal for special applications.

8. Backflow Prevention Assembly Installation Requirements:

- a. Approved backflow prevention assemblies shall not be modified in any way after the device leaves the manufacturer's factory.
- b. Backflow prevention devices shall be located in a room maintained at a minimum of 40° F and with electric illumination.
- c. Backflow prevention devices shall be installed where they are easily accessible for testing and maintenance.
- d. Acceptable facilities sized in accordance with the Uniform Plumbing

Code, such as floor drains, must be provided in the room in which the backflow prevention device is located to accommodate testing and maintenance procedures.

9. This Engineering Standard incorporates herein by reference the Cross Connection Control Manual of the Colorado Department of Public Health and Environment and the Colorado Primary Drinking Water Regulations of the Colorado Department of Public Health and Environment including all amendments made now or hereafter. Whenever there is a conflict between this Engineering Standard and the Colorado Cross Connection Control Manual, the most stringent standard will apply.

C. Identification of Hazards:

1. A clear understanding of cross-connection hazards is essential to the selection of appropriate backflow prevention measures. The applicability of an air-gap separation or of certain types of mechanical backflow prevention assemblies for resolution of a particular backflow condition depends upon the type of backflow and the degree of hazard. The degree of hazard is the actual or potential threat of contamination or pollution resulting from a cross-connection. A contamination hazard is an actual or potential threat of contamination, of a biological, physical or toxic nature, to Denver Water's system or the consumer's potable water system to a degree, which creates a hazard to public health. A potential hazard is an actual or potential threat of pollution to Denver Water's system, or the consumer's potable water system, which does not create a hazard to public health.

2. Based on national experience, premises where existing or potential contamination hazards present an imminent and substantial endangerment to public health must always be separated from public potable water systems by cross-connection control by containment. Similarly, existing or potential contamination hazards that present an imminent and substantial endangerment to public health within a consumer's premise, must always be separated from the consumer's potable water system by cross-connection control by isolation.

3. Those premises for which separation from Denver Water's system by containment is mandatory, are included in the list that follows:

- a. Unapproved auxiliary water supplies on premises, including private wells
- b. Premises where access is limited or restricted because of security concerns
- c. Hospitals, morgues, mortuaries, medical clinics, dental clinics, and autopsy facilities
- d. Laboratories
- e. Sewage treatment plants or facilities
- f. Food and beverage processing plants
- g. Chemical plants

- h. Metal plating industries
- i. Electrical and electronic component manufacturers
- j. Radioactive material processing plants
- k. Car and truck wash facilities
- l. Hydraulic testing facilities
- m. Packing houses, rendering plants, tanneries, and stock yard facilities
- n. Steam generating facilities
- o. Laundries, dry cleaners, laundromats
- p. Photographic film processing facilities
- q. Swimming pools and health spas
- r. Greenhouses
- s. Multi-storied buildings in excess of 30 feet above finished grade
- t. Fire protection systems
- u. Landscape irrigation systems
- v. Taxidermy shops
- w. Battery shops
- x. Kennels, pet shops
- y. Solar installations
- z. Printing shops, screen printing shops
- aa. Jewelry manufacturers
- bb. Radiator shops
- cc. Water service connections to commercial, industrial and institutional facilities

D. Special Applications:

1. Fire Protection Systems.

- a. An approved backflow prevention assembly shall be installed on any private fire protection system because of the following concerns:
 - 1) The growth of offensive microorganisms, which can create taste and odor problems.
 - 2) The leaching of heavy metals such as zinc, cadmium, iron, or lead into water which stands in pipelines for long periods of time.
 - 3) The addition of corrosion inhibitors or antifreeze compounds to protect the piping systems.
 - 4) Dry air systems containing compressed air.
 - 5) A loss of pressure on the public water supply main or an increase in pressure on the consumer's system which would allow water from these systems to flow backward into Denver Water's system.
- b. These hazards will vary from a non-health hazard to a health hazard. For this reason, it is required that all private fire systems must be protected from backflow. The protection will be commensurate with the

degree of hazard. Listed below are those situations which determine the different fire system hazards, and the type of protection required for each:

1) Low or Moderate Hazard Fire Systems:

- (a) Wet or dry with pumper connection.
- (b) Wet system with an in-line booster pump.
- (c) Any system with private hydrants
- (d) Any looped system (an inter-tied system with more than one service connection).

2) High or Severe Hazard Fire Systems:

- (a) Systems with pumper connections where corrosion inhibitors or other chemicals are added to the tanks of fire trucks.
- (b) All foamite plant installation.
- (c) Systems where an unapproved water supply can be connected to a fire system.
- (d) Systems in which antifreeze is allowed.

c. Backflow Protection Required:

1) Low or Moderate Hazard Fire Systems require an approved Double Check Valve Assembly.

2) High or Severe Hazard Fire Systems require an approved Reduced Pressure Principle Backflow Assembly.

d. Installation of backflow prevention assemblies on systems involving fire pumps shall have a low suction pressure shutdown provided with a minimum operating pressure of 10 psi.

e. When retrofitting an existing fire protection system, prior to installing a backflow prevention device, the design and the installation must be reviewed and approved by a licensed by the State of Colorado Professional Engineer experienced in fire protection. This review will involve an analysis of the existing fire protection system to ensure that the addition of the backflow prevention device will not adversely affect the fire protection system's performance.

f. When retrofitting an existing fire protection system, work shall be performed by a contractor registered with the State of Colorado, and where applicable, with the local fire protection authority, to work on fire protection systems.

g. In all cases, the water supplier is the final approval authority for installation of backflow prevention devices on fire protection systems.

2. Irrigation Systems

a. An approved backflow prevention assembly shall be installed on all water service connections that are used exclusively for landscape irrigation, and an approved backflow prevention assembly must be installed as an isolation device on residential, commercial, industrial, institutional, and public facilities that use the public water supply for lawn or landscape irrigation. Because landscape irrigation systems are subject

to cross connections due to flooding, agricultural chemicals such as fertilizers, pesticides, fungicides, soil conditioners, and from submerged outlets, auxiliary water supplies, ponds, reservoirs, swimming pools, and other sources of stagnant, polluted or contaminated water, these systems are considered to be actual or potential high or severe hazard situations.

1) Backflow protection in the form of approved atmospheric and pressure vacuum breakers are approved for use in landscape irrigation system, with the following exceptions:

- (a) Locations subject to flooding
- (b) Systems which are subject to back pressure conditions
- (c) Systems winterized by injection of compressed air
- (d) Systems which inject fertilizers or other chemicals

2) With the exception of landscape irrigation systems, pressure vacuum breakers are not approved for cross connection control by containment. Atmospheric vacuum breakers are not approved for cross connection control by containment or whenever there is a control valve located downstream of the device.

3) Air gap separations or reduced pressure principle backflow assemblies are required for irrigation systems subject to the following conditions:

- (a) Locations subject to flooding
- (b) Systems subject to back pressure conditions
- (c) Systems winterized by injection of compressed air
- (d) Systems which inject fertilizers or other chemicals
- (e) Premises that have auxiliary water sources available for irrigation

4) Double check valves are not approved for landscape irrigation systems.

3. Solar Heating Systems

a. An approved backflow prevention assembly must be installed on the water service line, as protection from cross connections, at any premise having a solar heating and/or cooling system that is connected to the consumer's water system, with the exception of a single-family residential premise, which must install an approved backflow prevention assembly as isolation protection from cross connections. The hazards normally found in solar heating and/or cooling systems include cross connections between the consumer's water system and:

- 1) Reservoirs and storage tanks
- 2) Solar collector fluids which may contain:
 - (a) Antifreeze compounds
 - (b) Toxic corrosion inhibitors
 - (c) Non-potable water

(d) Single wall heat exchangers between consumer's potable water and the collector fluids

(e) Negative pressure zones created by circulation pumps

3) Some solar water heating systems rely on non-toxic antifreeze solutions and/or non-toxic corrosion inhibitors. However, Denver Water has no assurance that these systems will not be subsequently altered to utilize a toxic fluid; therefore, the required protection shall be an approved reduced pressure principle backflow prevention assembly. It is to be used either as a containment device or as an isolation device.

6.12 Valve Boxes:

All buried gate valves 12 inches and smaller shall be provided with a 6 inch cast iron valve box, and large oval base. The valve box shall be of a design, which will not transmit shock or stress to the valve and shall have enough extension capability to be raised to final street grade. Valve boxes shall conform to [MS-11](#). The top section of the valve box shall be acceptable for use with a butterfly valve as shown on Sheet 18 of the [Standard Drawings](#).

6.13 Valve Reference Marker Posts:

When valves are installed where adequate physical reference points are not available, a valve reference marker post shall be required. Reference marker posts shall conform to Sheet 33 of the [Standard Drawings](#).

6.14 Meters:

Meters installed for billing purposes shall be under the control of Denver Water. No meter shall be installed until the proposed installation has been approved, and the meter tested and numbered by Denver Water.

Meters used to record usage by the retail consumer are called service meters. Meters used by wholesale customers and which supply water to other service meters are known as master meters. Other temporary meters may exist in the system for the purpose of Denver Water tests.

The characteristics which are of special importance in meters are accuracy and sensitivity, durability, low pressure loss, cost at purchase and installation, ease and low cost of maintenance, and compatibility with Denver Water's radio-frequency automatic meter reading system, using Itron ERT's (encoder-receiver-transmitter units). Registers and the associated Itron ERTs must be programmable using a standard ROCL program. Registers and ERTs using a WYSIWYG ROCL program are not acceptable. Pit ERTs shall be used for most pit installations of 5/8 inch, 3/4 inch and one inch meters and for some vault installations of larger meters. Remote ERTs shall be used for indoor meter installations and for some outdoor installations where there may be difficulty obtaining a drive-by reading from a public street.

Meter installations shall be inspected by Denver Water upon completion of the installation, prior to backfilling. Installations which do not comply with these Engineering Standards shall be made to conform prior to acceptance by Denver Water.

6.15 Size Of Meter:

Meters shall be of the same size as the corporation stop and that portion of the service pipe between the meter and the corporation stop. In no case shall a meter smaller than 3/4 inch be installed, except as a replacement for an existing smaller meter.

Denver Water may allow the installation of a meter of a size smaller than the service pipe in cases where the full capacity of a previously used service pipe is not required, provided that the service pipe is reduced to the size of the meter for a distance of not less than 10 times the larger pipe diameter on the inlet (supply) side of the meter or five feet, whichever is longer.

6.16 Type Of Meter:

The type of meter installed will be determined by Denver Water at the time of application based upon size, service requirements, location of meter and other conditions, which may exist.

6.17 Magnetic Drive Displacement Meters:

The displacement meters, known as nutating-disc or oscillating piston meters, are positive in action in that the pistons and discs displace or carry over a fixed quantity of water for each nutation or oscillation when operated under positive pressure. The magnetic drive displacement type water meter shall be furnished with a cast-iron "frost bottom" (also referred to as "frost-proof").

Meter sizes 1-1/2 inch and larger shall be brass, 2-hole, oval flange construction. Companion flanges shall be brass.

6.18 Compound And Turbine Meters:

Compound meters consist of two meters in a single case, one to measure small flows and the other to measure large flows. Some fireline meters are made with the two meters in separate cases coupled together as an integral unit. Compound meters are so designed that the small meter operates during low flows and as flows begin to increase, the large meter takes over. When the large meter is in operation the small meter may or may not be in operation.

Turbine meters are designed to measure primarily large flows, and should not be used where the possibility of small flows below the manufacturer's stated minimum flow exists.

All turbine meters size 3 inch and larger shall have a flanged in-line basket strainer installed on the upstream side. All turbine meters smaller than size 3 inch shall include an integral stainless steel strainer with removable top plate as described in MS 17-A.

In general, meters sizes 3 inches and larger for use as master meters, or in commercial, industrial, manufacturing, or irrigation uses, shall be turbine type meters conforming to [MS-17](#). Meters sizes 3 inches and larger, for uses other than those described for turbine meters, shall be compound type meters conforming to [MS-16](#).

In addition to the usage guidelines stated above, the provisions of [6.16](#) shall apply to the compound and turbine meters.

Compact fireline meters, a specialized type of compound meter, shall be used on any service which includes fire sprinklers, fire hydrants, or other fire protection behind the

meter, and in such other cases as may be determined by Denver Water. Fireline meters are required to meet specialized standards of Underwriters Laboratories and other certifying agencies.

Each register of each meter shall be furnished with an electronic encoder register and an Itron ERT. Devices designed to electronically combine the readings of multiple registers into a single ERT shall not be permitted. ERTs shall be mounted as directed by Denver Water Customer Service Field Section.

6.19 Outside Meter Settings:

All outside meters shall be installed in a horizontal position and housed in a concrete manhole or vault, and shall conform to Sheets 47, 48, 49, 50, 55, 56, 60, 61, 62, 63, 73, and 74 of the [Standard Drawings](#).

Each Water meter dial shall be equipped with an Itron ERT, mounted in accordance with Denver Water's standards. In most cases, the meter will be equipped with a pit ERT mounted through the meter pit/vault lid. In special circumstances, identified by the Customer Service Field Section, a remote ERT may be required at a distance of up to 250 feet from the meter pit or vault, mounted on the building or another structure. Signal wire for remote ERT installations shall be run through conduit.

6.20 Inside Meter Setting And Remote Readers:

Inside meter settings shall be installed in a manner which will allow free access and adequate room for inspection and maintenance and will protect the meter from freezing. Meter sizes 3/4 inch and one inch installed inside of buildings shall be located in a basement area, approximately 40 inches above the floor level, and not more than 18 inches from the wall through which the service pipe enters the building. See Sheet 51 and 52 of the [Standard Drawings](#). Meter sizes 1-1/2 inch and 2 inch installed inside buildings shall comply with Sheet 53 of the [Standard Drawings](#).

Inside meter settings shall not be allowed in crawl spaces, closets or other places where free and easy access is not provided. Meter sizes 1-1/2 inch and 2 inch installed inside buildings shall be equipped with a floor drain.

If the property owner proposed to enclose the meter or place it behind a wall, a suitable door or access panel shall be provided in conformance with Sheet 52 of the [Standard Drawings](#).

In buildings without basements, the water meter shall be installed indoors only under the following conditions:

- A.** The meter shall be installed in a heated utility room with a floor drain, and may not be installed in any space intended for continuous human occupancy.
- B.** The service line shall not exceed 60 feet in length, measured along the center line of the service pipe from the corporation stop to the inlet to the meter.
- C.** The meter shall be set in a location that will permit an acceptable remote ERT installation within 100 feet of the meter setting. The ERT shall be mounted on the inside or the outside of the front wall of the building.

Each water meter dial shall be equipped with an Itron remote ERT with 20-foot signal cable, mounted to maximize radio signal penetration. If the ERT signal cable length will exceed 20 feet, or if the wire is to be concealed behind a finished wall, the owner shall provide approved cable from the meter location to the ERT location, leaving enough extra cable at each end to make the spliced connections to the meter and the ERT.

6.21 Meter Bypass Lines:

A bypass line shall be required for all meters 1-1/2 inch and larger, except for meters intended solely to supply irrigation systems, unless otherwise specified by Denver Water, whether installed in an outside or inside setting. Bypass lines shall contain an independent control valve and shall contain no tees, plugs, or other outlets through which water could be withdrawn. Bypass lines permit the consumer to have water while their meter is being repaired or replaced. Bypass lines must be locked in the off position at all other times. Only a Denver Water employee is authorized to unlock and turn on a bypass line. Bypasses are not permitted on irrigation service lines.

6.22 Meter Check Valves:

Check valves will be required for all meters 1-1/2 inch and larger unless otherwise specified by Denver Water, whether installed in an inside or outside setting. Check valves may be required on meters smaller than 1-1/2 inch where any condition might exist that could cause a flow of water from the property to the main. Also see [6.09](#). Check valves are not required when a backflow prevention device is installed on the service line downstream of the meter.

6.23 Valves For Use With Meters:

Type of valve for size 2 inches and smaller shall depend on the size and type of setting as follows:

- A.** For inside and outside meter settings for a 1-1/2 inch or 2 inch meters, as shown on Sheet 55 and 56 of the [Standard Drawings](#) curb stop valves are required.
- B.** For an inside meter setting for a 3/4 inch or one inch meter, as shown on Sheets 49, 50 & 51 of the [Standard Drawings](#), a stop-and-waste valve shall be installed on the supply side of the meter and a gate valve shall be installed downstream (on the building side) of the meter.
- C.** For an outside meter setting for a 5/8 inch x 3/4 inch, 3/4 inch or one inch meter, as shown on Sheets 48 and 49 of the [Standard Drawings](#), an angle valve is required in the meter pit as part of the meter setting. (**Note:** 5/8 inch x 3/4 inch meters may only be used to replace existing meters of the same size; if the meter setting is changed, it must be upgraded to a 3/4 inch setting and meter.)

All valves shall be in accordance with [MS-21](#).

Valves 3 inches and larger for use with cast or ductile iron service pipe shall be gate valves conforming to [MS-4](#), or resilient seated gate valves in accordance with [MS-4A](#), except they shall have mechanical joints on both ends. All gate valves larger than 3 inches for use with meters shall be supported by adjustable steel valve supports. This

support shall conform to Sheet 39 of the [Standard Drawings](#).

See also [3.10](#).

6.24 Meter Couplings:

Meters 3 inches and larger shall be installed with a coupling to allow removal of the meter without disturbing the pipe. Couplings shall conform to [MS-22](#).

6.25 Meter Yokes (Line Setters):

A yoke is a metal pipe frame attached to the inlet and outlet sides of the meter providing support, and conveying water to the meter. Meter yokes shall conform to [MS-21](#).

To assure safety, the water meter setting shall provide a continuous, electrically conductive, path around the water meter. If a bonding jumper is required, it shall be made of copper with fittings suitable for the bonding jumper and the water pipe material. The meter setting installation shall be in compliance with the NEC.

6.26 Valve And Meter Supports:

Meter supports shall be a solid concrete block as shown on Sheets 55, 56, 69, 60, and 62 of the [Standard Drawings](#). Fabricated metal supports shall be used to support valves 3 inches and larger and shall conform to Sheets 59, 60, 62, 74, and 76 of the [Standard Drawings](#).

6.27 Meter Pits And Covers For 3/4 inch And One inch Meters:

Meter pits shall consist of four 12 inch pre-cast concrete rings or any combination of pre-cast concrete rings that total 48 inches in height. The rings shall have a 2 inch minimum wall thickness. The rings shall be constructed of concrete in accordance with [MS-18](#) and comply with all requirements of ASTM C 478. Plastic meter pits are not permitted. An aluminum dome or bell housing shall be mounted on the top of the pit; the dome or bell housing shall have a support for an interior frost lid and a rim for locking the meter pit cover. The meter pit cover shall have a cast iron, cap type, top lid, with a recess to hold the Itron ERT. There shall be a 2 inch diameter hole to accommodate the ERT, and not less than three drainage holes within the recessed area to prevent the buildup of water and ice. An alternative meter pit cover is one made of polymer-concrete composite material with integral supports for the Itron Pit ERT. All meter pit covers shall have a locking screw and bolt that provides a tight locking of the cover to the dome or bell housing of the meter pit. See Sheet 49 of the [Standard Drawings](#) and [MS-23](#). The inner frost lid shall be high density polyethylene. The frost lid shall be dish shaped, with a 3 inch depth, and shall have three to five drainage holes and an integral lifting handle. See Sheet 49 of the [Standard Drawings](#) and [MS-23](#).

6.28 Vaults:

Vaults may be pre-cast or cast-in-place. Pre-cast vaults shall be so designed that all joints and corners are waterproof. The roof and walls of pre-cast and cast-in-place vaults shall be made waterproof after construction by use of sealants, epoxies or other approved methods.

If the vault is not to be in a street, the roof shall be designed to support the overhead

earth fill and any other reasonable loading that may occur. If the vault is to be built in a street, the roof shall be designed to support the street fill and HS-20 traffic loading in accordance with AASHTO Standards. However, if there is any doubt, the vault shall be designed for the traffic loading. Particular care shall be taken in selecting pre-cast vaults that the application not be one of either shallow or deep cover over the roof. Should the cover over the roof be less than 2-1/2 feet or more than 5 feet, concern for adequacy of the roof, or the ability to remove and replace a one piece roof slab resting upon deflecting side walls may dictate a cast-in-place vault.

Automatic meter reading ERTs shall be mounted inside the vault, in a remote location on the side of a building or on a pole, or through the access cover to maximize radio signal penetration.

Cast-in-place meter vaults shall conform to Sheets 60 through 63 and 74 through 77 of the [Standard Drawings](#). See [MS-18](#), [MS-19](#), [MS-21](#) and [MS-26](#).

6.29 Concrete Structures:

Structures shall be designed to support applicable loads. Design calculations, drawings, and contract specifications shall be submitted to Denver Water for review.

Concrete used in structures shall be Class "A". See [MS-18](#), and [8.21](#).

6.30 Steel Reinforcement For Concrete:

Steel reinforcement shall be either deformed bars or welded steel fabric and shall conform to [MS-20](#).

6.31 Manholes:

Manholes, reducing sections, ladder rungs, and traffic lids shall be pre-cast concrete and conform to ASTM C 478 and [MS-18](#). All traffic lids shall be designed for HS-20 traffic loading in accordance with AASHTO Standards. All ladder rungs or manhole steps shall be cast into the manhole barrel when the manhole barrel is cast.

Concentric reducing sections shall not be used. The top of the manhole vault shall be a minimum of 12 inches and a maximum of 18 from the official street or ground surface elevation. Concrete extension collars shall be used to bring the manhole ring and cover up to official street or ground surface elevation. These grade rings shall be constructed of concrete in accordance with [MS-18](#), and shall comply with the requirements of ASTM C 478.

Manhole rings and covers:

- A.** Twenty-four inch manhole rings and covers shall be "City of Denver, Colorado Standard" pattern. Twenty-four inch cover weighs approximately 165 pounds. Twenty-four inch ring weighs approximately 240 pounds.
- B.** Twenty-four inch x 36 inch double ring and cover: The 36 inch cover shall have an auxiliary 24 inch opening and cover. Thirty-six inch cover weighs approximately 250 pounds. Thirty-six inch ring weighs approximately 280 pounds.

6.32 Manhole Base Slabs And Base Beams:

Manhole base beams shall be pre-cast, reinforced concrete. The beams shall be 12 inches wide by 9 inches deep by 8 feet long. The reinforcement shall consist of three No. 5 bars, evenly spaced, and No. 4 bars at 12 inch centers transversely.

Manhole base slabs may be cast-in-place or pre-cast. The slab shall be designed to uniformly support the earth load and any other reasonable loads that may occur. The minimum slab thickness shall be 6 inches. The minimum reinforcement shall be welded wire fabric, 4 x 4 - W4 x W4. Splicing of the welded wire fabric shall be by lapping one space and securing the wire mesh together. The concrete shall conform to [MS-18](#) and the reinforcement shall conform to [MS-20](#).

6.33 Sump Pits For Vaults And Manholes:

Sumps are required for vaults or manholes in areas where there is seepage into existing vaults and in all pressure regulating valve installations.

A gravity drain line or sump pump shall be used in conjunction with a sump where telemetry equipment is to be installed. See Sheets 43 and 45 of the [Standard Drawings](#).

Normal practice in constructing a sump is to excavate a 30 inch diameter hole about 3 feet deep. A 6 inch floor is placed and allowed to set. Then a 24 inch section of cardboard tubing is used for an inside form, and concrete is poured behind it approximately 3 inches thick. See Sheets 43 and 44 of the [Standard Drawings](#) showing a sump as part of a typical pressure regulating valve installation.

6.34 Vent Pipes:

Vent pipes are used in vaults and pits to provide proper ventilation. Installations that contain electrical equipment shall have a locally controlled, power operated blower attached to the vent system. Vent pipes shall be field located at the nearest intersection of the street property line and the side lot line. See Sheets 40 through 42 of the [Standard Drawings](#) for vent pipe installation details. A residential vent pipe assembly as shown in Sheet 40 may be used where an inconspicuous installation is desirable.

Above ground vent pipe shall be 6 inch nominal diameter galvanized steel pipe, conforming to ASTM A 53. The vent screen shall be a 3/4 inch No. 9-11 flattened expanded galvanized metal screen. See Sheet 41 of the [Standard Drawings](#). Below ground vent pipe shall be 6 inch, schedule 40 PVC with glued joints. A PVC glued joint by standard pipe thread female adapter shall be used to connect the steel pipe to the PVC pipe at ground level. Where the residential vent pipe assembly is used this adapter is not needed. PVC pipe is not allowed with 8 foot above ground risers.

6.35 Manufacturer And Model Of Fire Hydrants:

Within the City and County of Denver and Total Service Areas, where maintenance, repair, replacement, and parts stocking is the responsibility of Denver Water, only the four manufacturer's brands of hydrants listed in [MS-12](#), are acceptable.

In Distributor Contract Areas, fire hydrants conforming to [MS-12](#), but without limitation to the brand names chosen by Denver Water for their own use, shall be used. Any brand and model used, however, must have prior Denver Water approval. Two such brands which have met approval are listed in [MS-12](#).

6.36 Fireline Connections To Mains:

Firelines supplying sprinklers shall be sized by the appropriate fire protection bureau and the persons responsible for the structure it protects. Denver Water will not size firelines.

The fireline shall be restrained ductile iron pipe. A fireline shall have a valve 2 feet from the property line on the street side of the property line as shown on Sheet 35 and 36 of the [Standard Drawings](#).

6.37 Service Lines:

Service lines shall be sized to adequately supply the requirements of the property being served. The minimum size line shall be 3/4 inch. The only acceptable material for a service line is seamless copper tube, Type K (soft) for sizes through 3 inch and ductile iron pipe for sizes 3 inches and larger. Service lines shall be of the same type material from beginning to end, unless the appropriate insulator is installed at the junctions of the dissimilar metals. See [3.09](#), [MS-1](#) and Sheets 48 and 50 of the [Standard Drawings](#).

Unless otherwise approved by the Customer Service Field Section, there shall be no bends or changes in the size of the service line between the tap and a point five feet past the meter pit or vault for outdoor meter settings, or between the tap and a point five feet past the curb stop for indoor meter settings.

6.38 Corporation Stops:

Corporation stops provide the connection for the service line to the main. By utilizing a corporation stop, a service can be connected to the main without taking the main out of service. Corporation stops are also used in air and vacuum valve and large butterfly valve installations as shown in Sheets 16 through 18 of the [Standard Drawings](#). Corporation stops are made in standard sizes 3/4, one inch, 1-1/2 inch, and 2 inch. See Chapter 3, [MS-21](#) and Sheets 48 and 50 of the [Standard Drawings](#).

6.39 Curb Stops:

Curb stops are set on the service line near the property line and provide a means to shut off the service line. For outside meter settings, the curb stop must be placed from two to five feet from the inlet side of the meter pit. Placement of the curb stop and stop box may vary from a maximum of 5 feet outside the property line (in the street or easement) to a maximum of 5 feet inside the property line (on the customer's property). Placement of the curb stop and stop box outside the property line is preferred. Curb stops and boxes will be located in landscaped areas unless otherwise approved by the Customer Service Field Section. Where the curb stop must be placed beneath a roadway, street or parking lot, it shall be located where vehicles can not park over it. See Sheets 48 and 50 of the [Standard Drawings](#) and [MS-21](#) for further details.

6.40 Curb Stop Service Boxes:

Curb stop service boxes shall be cast iron, Buffalo type. The bottom part shaped like an inverted U straddling the service line shall have a flanged bottom so as to support itself. Curb stop service boxes shall conform to [MS-22](#).

6.41 Corrosion Protection Systems:

Metallic pipe and fittings shall be protected against corrosion.

A. Polyethylene Encasement Material: Polyethylene wrap shall be used on all cast iron or ductile iron pipe, fittings, rods, and appurtenances where the soil resistivity is greater than 1,000 ohm-centimeters. Polyethylene material shall conform to [MS-13](#) and Sheet 38 of the [Standard Drawings](#).

Twenty-four inch flat width tubing shall be used with 4 inch, 6 inch, and 8 inch pipe. Thirty inch flat width tubing shall be used with all 12 inch pipe. Thirty-six inch flat width tubing shall be used for 16 inch pipe. Fifty-two inch flat width tubing shall be used with 20 inch and 24 inch pipe.

Harness rods shall be covered by 4 inch flat width polyethylene tubing. The entire joint shall be covered by a cigarette-wrap of 48 inch wide polyethylene sheet material over each set of lugs. Irregular shaped valves and fittings shall be covered with flat 48 inch wide polyethylene sheet material.

B. Insulators: Insulators shall be installed at the outlet end of the corporation stop as shown on Sheets 48 and 50 of the [Standard Drawings](#). Insulators shall be in accordance with [MS-22](#). See Sheet 37 of the [Standard Drawings](#) and [MS-22](#) for other insulators, which may be required.

6.42 Kickblocks:

Concrete kickblocks shall be sized for the working pressure plus water hammer surge pressures as stated in 6.03 and the soil bearing capacity. Standard shapes and sizes of kickblocks are shown on Sheets 19 and 20 of the [Standard Drawings](#).

The kickblocks shall be of Class B concrete conforming to [MS-18](#), or of a pre-measured, sacked industrial mix such as Sakcrete, Dri-mix, or an approved equal. Ready-mixed concrete mixes shall be approved by Denver Water.

6.43 Protective Concrete Pads Over Pipe:

Under unusual circumstances it may be necessary to lay pipe at shallow depths. Concrete pads shall be used over the pipe to protect it from the traffic loading. The pads shall be designed to support loads from traffic without transmitting the load, to the pipe. Approved Insulation as approved by Denver Water shall be required between the pipe and the concrete pad to protect the pipe from frost. This situation, and its solution, shall be subject to approval by Denver Water.

6.44 Casing Pipe:

Installation of mains through Denver Water rights-of-way or rights-of-way or easements of others, such as highways, railroads, etc., may require casing pipes to facilitate the installation of the main. The type of casing material and its properties will be specified by the agency granting permission to cross. Such crossing shall be subject to approval by Denver Water to avoid conflicts in requirements or standards between Denver Water and the persons or agency granting permission to cross.

See Sheets 28 and 29, of the Standard Drawings for details. Final approval of the boring and casing methods and materials shall be obtained from Denver Water prior to construction. Where a bore is not required to cross interference, Denver Water may require the installation of the main under the interference in conformance with Sheet 28

and 29 of the [Standard Drawings](#).

6.45 Miscellaneous Metalwork And Piping:

All fabrication shall be equal to the best practice in modern fabricating shops. Welding shall be performed by certified welders, with all exposed welds ground smooth. All weld splatter shall be properly removed to the satisfaction of Denver Water.

All exposed hardware, including nuts, washers, bolts and anchor bolts, shall be galvanized.

All exposed metal that is to be buried shall be given two coats of CA-1200 mastic cold coating as manufactured by Protecto Wrap Company, Denver, Colorado, or equal, except for metal with shop applied coating approved by Denver Water.

All metal exposed to weather shall be painted with one coat of a rust inhibiting priming paint and two coats of aluminum paint, unless otherwise directed by Denver Water. Surfaces to be painted shall be cleaned of oil, grease, weld spatters, burrs, grit, dust or other objectionable surface irregularities. Cleaning solvent used shall be mineral spirits. Copper, aluminum or galvanized pipe need not be painted, unless so directed by Denver Water.

All miscellaneous piping shall be installed in the best workmanlike manner. All threads on steel pipes shall be cut with sharp dies to standard depth, left clean cut, and tapered. Threaded pipe joints shall be properly sealed with an approved joint compound applied on the male threads only.

All concealed joints for copper water tubing within buildings shall be soldered or brazed in conformance with the appropriate building code. The joint of the copper pipe shall be properly cleaned, flux applied, and soldered with 95-5 tin-antimony solder, all applied in accordance with the best plumbing practice. All parts to be soldered shall be thoroughly cleaned before flux is applied. All copper piping, where the pipe is in direct contact with pipe hangers or other metal supports, shall be protected with a copper saddle soldered to the underside of the pipe. Saddles may be made of split copper pipe.

All copper joints installed underground shall be flared or brazed. Flaring and brazing shall be performed with the best plumbing practices.

6.46 Air And Vacuum Release Valves:

Combination air release and vacuum relief valves shall be required for Conduits and may be required for transmission mains at the discretion of Denver Water. Air release and vacuum valve assemblies as shown on Sheet I6 and 17 of the [Standard Drawings](#) shall be installed at high points in the Conduit, where there is an abrupt change of slope and at line valves where the Conduit slopes away from the valve or as determined by Denver Water. See [MS-10](#).

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 7 – Earthwork

7.01 Earthwork Defined:

Earthwork shall include clearing, grubbing, grading, excavation, fill, backfill, excess excavation, bedding and pipe zone material, borrow material, and surface restoration that may be required to complete the work.

7.02 Exploratory Excavation:

Underground utilities and structures that may interfere with construction shall be exposed and the location verified sufficiently in advance to permit necessary relocations without delays.

7.03 Excavation To Line And Grade:

Excavations shall be made to the lines and grades as established by the approved plans. Pipe trenches shall be excavated to a minimum depth of 6 inches below the bottom of the pipe. Deviation from grades will be allowed when approved by Denver Water, in accordance with [8.06](#) and [8.07](#).

7.04 Trenching Operations:

A. Trench Width: Existing asphalt or concrete surfacing shall be cut vertically in a straight line, and removed from the jobsite prior to starting the trench excavation. This material shall not be used in any fill or backfill.

The trench shall be excavated so that a minimum clearance of 6 inches shall be maintained on each side of the pipe for proper placement and densification of the bedding and pipe zone or backfill material. The maximum trench width, measured at the top of the pipe shall be the outside diameter plus 24 inches regardless of the type of pipe, type of soil, depth of excavation or the method of densifying the bedding and backfill. See Sheet 10 of the [Standard Drawings](#).

B. Trench Support: The trench shall be adequately supported and the safety of workers provided for as required by OSHA.

Sheeting and shoring shall be utilized where required to prevent any excessive widening or sloughing of the trench, which may be detrimental to human safety, to the pipe or appurtenances being installed, to existing utilities, to existing structures, or to any other existing facility or item.

Excavated material shall not be placed closer than 2 feet from the top edge of the trench. Heavy equipment should not be used, or placed, near the sides of the trench unless the trench is adequately braced.

7.05 Excavation For Structures:

Except as otherwise dictated by construction conditions, the excavation shall be of such dimensions as to allow for the proper installation and removal of concrete forms, or pre-cast slabs and panels, and to permit the construction of the necessary pipe connections. Care shall be taken to insure that the excavation does not extend below established grades. If the excavation is made below such grades, the resulting excess excavation shall be filled in with sand or graded-gravel, deposited in horizontal layers not more than 6 inches in thickness after being compacted, and shall be moistened to within 2 percent of the optimum moisture content required for compaction of that soil. After being conditioned to have the required moisture content, the layers shall be compacted to the density as specified in 7.11.B.

7.06 Surplus Excavation Material:

All surplus excavation shall be removed from the jobsite and disposed of properly. If the surplus excavation is disposed of on private property, written permission shall be obtained from the owner and a copy given to Denver Water.

7.07 Blasting:

In general, blasting will be allowed in order to expedite the work if a permit by the local authority having jurisdiction is granted. All explosives and appurtenances shall be transported, handled, stored and used in accordance with the laws of the local, state, and federal governments, as applicable.

All blasting shall be controlled so as not to injure any existing structure or facility. The hours of blasting shall be fixed by Denver Water. Owners or occupants of nearby structures or facilities shall be notified at least 72 hours in advance of blasting, in writing. The notice shall state the date, the time of blasting and who is responsible for the blasting.

Blasting shall be controlled so as not to make any excavation unduly large or irregular as to shatter the rock on the bottom or sides of any excavation or surface upon or against which concrete is to be placed. If, in the opinion of Denver Water, blasting is liable to damage rock foundations or supports, concrete or structures, all blasting shall be terminated and excavation shall be continued by jackhammering, barring, wedging or other methods.

Blasting in a trench shall not be done until the trench walls have been shored or braced in a manner satisfactory to Denver Water. All liability for blasting shall be placed solely on the person or persons conducting the blasting operation.

7.08 Dewatering:

All pipe trenches or structure excavation shall be kept free from water during pipe laying and other related work. The method of dewatering shall provide for a completely dry foundation at the final lines and grades of the excavation.

Dewatering shall be accomplished by the use of well points, sump pumps, rock or gravel drains placed below subgrade foundations or subsurface pipe drains. All water shall be

disposed of in a suitable manner without being a menace to public health or causing public inconvenience in accordance with any required permit. No water shall be drained into other work being completed or under construction.

The dewatering operation shall continue until such time as it is safe to allow the water table to rise in the excavations. Pipe trenches shall contain enough backfill to prevent pipe flotation of the carrier or casing pipe. When pipe is laid in a casing or tunnel longer than 30 pipe diameters, the pipe inside said casing or tunnel shall be secured so flotation does not occur when the pipe is empty.

Water shall not be allowed to rise until the concrete has set a minimum of 24 hours, and the forms have been removed. Water shall not be allowed to rise unequally against unsupported structural walls.

7.09 Foundations On Unstable Soil:

If the bottom of the excavation is soft or unstable, and in the opinion of Denver Water, cannot satisfactorily support the pipe or structure, a further depth and width shall be excavated and refilled to 6 inches below grade with rock uniformly graded between 3/4 inch and 1-1/2 inch.

7.10 Pipe Bedding And Pipe Zone Material:

A. Installation of Bedding and Pipe: After completion of the trench excavation and proper preparation of the foundation, 6 inches of bedding material shall be placed on the trench bottom for support under the pipe. Bell holes shall be dug deep enough to provide a minimum of 2 inches of clearance between the bell and bedding material. All pipe shall be installed in such a manner as to insure full support of the pipe barrel over its entire length. After the pipe is adjusted for line and grade, and the joint is made, the pipe zone material shall be carefully placed and tamped under the haunches of the pipe and in the previously dug bell holes.

Tamping is herein defined as the act of placing approved pipe zone material under the haunches of the pipe, paying particular attention to voids, bell hole, and sling holes. The purpose of tamping is to ensure uniform support for the pipe.

The limits of bedding and pipe zone material shall be from 6 inches below the bottom of the pipe to 6 inches above the top of the pipe. Approved backfill may then be installed to the ground line. For backfill and compaction of backfill see [7.11](#).

Compaction of bedding is not required. The only requirement is sufficient tamping to achieve uniform support under the pipe. See Sheet 10 of the [Standard Drawings](#) for a typical trench cross section.

B. Type of Bedding and Pipe Zone Material: The bedding and pipe zone material shall be a clean, free draining well-graded sand or squeegee sand and shall conform to the following limits when tested by means of laboratory sieves:

Well Graded Sand

Sieve Size	Total Percent Passing by Weight
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3/8 inch	100
No. 4	70-100
No. 8	36- 93
No. 16	20- 80
No. 30	8- 65
No. 50	2- 30
No. 100	1- 10
No. 200	0- 3

Squeegee Sand

Sieve Size	Total Percent Passing by Weight
3/8 inch	100
No. 200	0-3

Approved bedding and pipe zone material shall be stockpiled on the jobsite to be used in the event natural materials become unsatisfactory. Denver Water reserves the right to require the use of the specified bedding and pipe zone material at any time.

7.11 Backfill And Compaction:

A. Pipes: The pipe trench shall be backfilled to the limits as shown on Sheet 10 of the [Standard Drawings](#). The backfill shall be compacted by vibrating, tamping, or a combination thereof, to 70% relative density for sand material as determined by ASTM D 4253 and D 4254, or to 95 percent of maximum dry density for cohesive soils as determined by ASTM D 698.

It is expected that the trench excavation will provide suitable backfill material. Wet, soft, or frozen material, asphalt chunks, or other deleterious substances shall not be used for backfill. If the excavated material is not suitable for backfill, as determined by Denver Water, suitable material shall be hauled in and utilized, and the rejected material hauled away and disposed of properly.

Backfilling shall be conducted at all times in a manner to prevent damage to the pipe or its coating and shall be kept as close to the pipe laying operation as possible. Backfilling procedures shall conform to the additional requirements, if any, of appropriate agencies or private right-of-way agreements.

B. Structures: Backfill and fill within 3 feet adjacent to all structures, and for full height of the walls, shall be selected nonswelling material. It shall be relatively impervious, well graded, and free from stones larger than 3 inches. Material may be job excavated, but selectivity will be required.

Stockpiled material, other than topsoil from the excavation, shall be used for backfilling unless an impervious structural backfill is specified. The backfill material shall be free from rubbish, stones larger than 3 inches, clods, and frozen lumps of soil. All backfill around the structures shall be consolidated by

mechanical tamping. The material shall be placed in 6 inch loose lifts within a range of 2% above to 2% below the optimum moisture content and compacted to 95% of maximum dry density for cohesive soils as determined by ASTM D 698 or to 70% relative density as determined by ASTM D 4253 and D 4254.

Impervious structural backfill, where shown or specified, shall consist of material having 100% finer than 3 inches in diameter and a minimum of 20% passing a No. 200 U.S. Standard sieve. The material shall be placed in 6 inch loose lifts within a range of 2% below the optimum moisture content, and compacted to 95% of maximum dry density as determined by ASTM D 698.

7.12 Controlled Low Strength Material (CLSM):

Permission to use CLSM commonly called "Flow Fill" or "Flowable Concrete Backfill" shall be requested from Denver Water for backfill in pipe zone and other backfill locations. The request to use CLSM shall be in writing and include a mix design from a ready-mixed concrete producer. CLSM shall conform to [MS-19](#).

7.13 Cleanup:

Upon completion of the work, all rubbish, unused materials, concrete forms and other like material shall be removed from the jobsite. All excess excavation shall be disposed of as specified and the areas shall be left in a state of order and cleanliness.

7.14 Surface Restoration:

A. Unsurfaced Areas: All surface cuts shall be, as a minimum, restored to a condition equal to that prior to construction. All streets shall be restored in accordance with the regulations and requirements of the agency having control or jurisdiction over the street, roadway, or right-of-way.

B. Surfaced Areas: All surface cuts shall be, as a minimum, restored to a condition equal to that prior to construction. All gravel or paved streets shall be restored in accordance with the regulations and requirements of the agency having control or jurisdiction over the street, roadway, or right-of-way.

C. Easements, Cultivated or Agricultural Areas: In easements, cultivated or agricultural areas, topsoil, to a depth of 8 inches, shall be removed from the area of general disturbance and stockpiled. After installation of all pipelines, appurtenances and structures, and completion of all backfill and compaction, the stockpiled topsoil shall be redistributed evenly over all disturbed areas. Care should be taken to conform to the original ground contour or final grading plans.

7.15 Subgrade And Road Preparation:

Prior to installation of water mains in dedicated streets, road construction must have progressed to at least the subgrade stage. Subgrade elevation is defined as an elevation which lies no more than 7 inches below the finished street grade. The road surface shall be smooth, clear of debris and free from deep holes, ruts, and large rocks which may hamper main installation.

Mains shall be laid where the ground surface is near its final elevation, whether it is located in a dedicated street or not.

Engineering Standards - Chapter 7:
Revised 07-04, Previous Revision 05-02
End

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 8 – Pipe Installation

8.01 Approval By Denver Water:

Many handling and installation procedures, tools, equipment, and materials require approval by Denver Water. Approval by Denver Water shall in no manner render Denver Water liable for any injuries suffered or equipment damaged. Approval by Denver Water is used solely as a means to insure quality control.

Safety of workers shall be provided as required by OSHA.

8.02 Handling Of Materials:

Pipe and fittings shall be loaded and unloaded by lifting so as to avoid shock or damage. Under no circumstances shall such material be dropped. If, however, any part of the coating or lining is damaged, the replacement or repair of the damaged pipe shall be done to the satisfaction of Denver Water. Any pipe or fittings that are not acceptable to Denver Water shall be removed from the job site immediately. Pipe handling equipment and pipe handling methods shall be approved by Denver Water.

8.03 Preparation And Inspection Of Pipe And Fittings For Installation:

Before placing pipe in the trench, each pipe or fitting shall be thoroughly cleaned of all foreign material, kept clean at all times thereafter, and carefully examined for cracks and other defects before installation. Bell ends and spigot ends are to be examined with particular care.

8.04 Pipe Joint Lubricant:

Joint lubricant shall be as supplied by the pipe manufacturer, and approved by Denver Water. Joint lubricant shall be non-toxic, water soluble, and certified to meet NSF Standard 61.

8.05 Cutting And Fitting Of Pipe:

Pipe shall be cut, whenever necessary, to conform to location of fittings, line, or grade. All cuts shall be straight and true, in a workmanlike manner so as to leave a smooth end without damaging the pipe. All burrs shall be removed from the ends of cut pipe, and the end lightly rasped or filed. All tools used in cutting pipe shall be approved by Denver Water.

Power-driven saws with abrasive discs (masonry blades) shall **not** be used for *dry* cutting or beveling asbestos-cement pipe. In recognition of efforts to reduce the incidence and corresponding danger of airborne asbestos fibers, MOA PVC pipe may be used in place of MOA asbestos-cement pipe wherever cutting is necessary.

8.06 Pipe Alignment And Grade:

In laying pipe, the intent is to lay to set line and grade within a tolerance of 3 inches plus or minus. On slopes of zero grade, the intent is to lay to grade. Fittings, valves, and hydrants shall be installed at specified locations and elevations.

When laying pipe on curves, the intent is to lay to the alignment. The pipe shall be kept in alignment by placing the joints or bends on the curve. Short lengths shall be used as necessary to accomplish the curvature without exceeding individual deflections specified by the pipe manufacturer. Bends shall be used whenever individual deflections exceed those specified by the manufacturer.

For all pipes the depth of cover over the pipe measured from official street grade to the top of the pipe shall be a minimum of 4-1/2 feet and shall be known as the cover over the pipe. If difficulties arise when crossing interference and where specifically approved by Denver Water, deviations from 4-1/2 feet of cover will be permitted. Cover over the pipe shall be a minimum of 3 feet and a maximum of 10 feet.

Any changes in alignment and grade shall be authorized by Denver Water and shall be accomplished by the installation of additional fittings. Breaking of joints is permitted only when installing pipe on horizontal or vertical curves.

Pipe shall be laid with bell ends facing the direction of laying, unless directed otherwise by Denver Water.

8.07 Deviation From Alignment And Grade Occasioned By Other Structures:

Whenever obstructions not shown on the plans interfere to such an extent that an alteration in the plans is required, Denver Water shall have the authority to determine the best method of correction. Denver Water's Inspector may change the plans and order a deviation from line and grade, or arrangements may be made with the owners of the structure for its removal, relocation, or reconstruction.

8.08 Temporary Bulkheads:

Whenever the pipe is left unattended, temporary plugs shall be installed at all openings. Temporary plugs shall be watertight and of such design as to prevent children and animals from entering the pipe. All temporary plugs shall be approved by Denver Water.

8.09 Frost:

No pipe or appurtenant structure shall be installed upon a foundation into which frost has penetrated, or at any time when Denver Water deems there is danger of ice formation, or frost penetration at the bottom of the excavation. No pipe or appurtenant structure shall be installed unless backfilling can be completed before the formation of ice and frost.

8.10 Ductile Iron Pipe:

A. Push-on Joint: Immediately before joining two lengths of ductile iron pipe, the inside of the bell, the outside of the spigot end, and the rubber gasket shall be thoroughly cleaned to remove oil, grit, excess coating, and other foreign matter. The rubber gasket shall be flexed inward and inserted in the gasket recess of the bell socket. Caution shall be exercised to ensure the correct type of gasket is used.

A thin film of joint lubricant shall be applied to either the inside face of the gasket, or the spigot end of the pipe, or both.

The spigot end of the pipe shall be placed in the bell end with care to prevent the joint from contacting the ground. The joint shall be completed with a slow, steady pressure without jerky or jolting movements. Pipe furnished without a depth mark shall be marked before assembly to assure insertion to full depth of the joint. The spigot end of field cut pipe lengths shall be filed, or ground to resemble the spigot end of such pipe as manufactured.

B. Mechanical Joint: Before joining mechanical joint cast iron fittings to ductile iron pipe, the outside of the spigot, the inside of the bell, and the rubber gasket shall be thoroughly cleaned to remove oil, grit, excess coating, and other foreign matter.

Normal practice is to lubricate the joint with a soap solution; however, in cold weather the joint may be assembled dry if approved by Denver Water. Extreme care shall be exercised in making dry joints.

The gland shall be slipped on the spigot end of the pipe with the lip extension of the gland toward the socket, or bell end. The rubber gasket shall be placed on the spigot end with the thick edge toward the gland.

The pipe shall be pushed in until the spigot end fully penetrates the bell. The gasket shall then be pressed into place within the bell evenly around the entire joint. The cast iron gland shall be moved along the pipe into position for bolting; the bolts inserted, and the nuts screwed finger tight, then tightened with a torque limiting wrench. Torques for the various sizes of bolts shall be as follows:

Pipe Size (inches)	Bolt Size (inches)	Range of Torque (foot-pounds)
3	5/8	45-60
4-24	3/4	75-90
30-36	1	100-120
42	1-1/4	120-150

Nuts spaced 180 degrees apart shall be tightened alternately in order to produce equal pressure on all parts of the gland.

All mechanical joint fittings shall be wrapped with polyethylene encasement material in accordance with [6.41 A](#).

C. Bolted Sleeve Type Couplings: When installing bolted sleeve type couplings,

care shall be taken that the connecting pipe ends, couplings, and gaskets are clean and free of all dirt and foreign matter with special attention given to the contact surfaces of the pipe, gaskets, and couplings. These couplings shall be assembled and installed in conformity with the recommendation and instructions of the coupling manufacturer.

Bolted sleeve type couplings shall be wrapped with polyethylene encasement material in accordance with [6.41 A](#).

Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Coupling bolts shall be tightened so as to secure a uniform annular space between the end rings and the body of the pipe and all bolts tightened approximately the same amount. Diametrically opposite nuts shall be tightened progressively and evenly. Final tightening shall be done with a torque limiting wrench set for the torque recommended by the coupling manufacturer.

8.11 Polyvinyl Chloride Pressure Pipe:

A. Elastomeric Gasket Joint: Immediately before joining two lengths of PVC pipe, the inside of the bell or coupling, the outside of the spigot and the elastomeric gasket shall be thoroughly cleaned to remove all foreign material.

Lubrication of the joint and rubber gasket shall be done in accordance with the pipe manufacturer's specifications.

Care shall be taken that only the correct elastomeric gasket, compatible with the annular groove of the bell, is used. Insertion of the elastomeric gasket in the annular groove of the bell or coupling shall be in accordance with the manufacturer's recommendations. Pipe that is not furnished with a depth mark shall be marked before assembly to assure that the spigot end is inserted to the full depth of the joint.

The spigot and bell or coupling shall be aligned and pushed until the reference line on the spigot is flush with the end of the bell or coupling. Pushing shall be done in a smooth, steady motion.

B. Pipe Storage: Pipe stored outside, and exposed to sunlight for more than 30 days, shall be covered with an opaque material such as canvas. Clear plastic sheets shall not be used to cover pipe. Air circulation shall be provided under the covering.

C. Handling of Pipe in Cold Weather: PVC pipe has reduced flexibility and impact resistance as temperatures approach and drop below freezing. Use extra care should be used in handling PVC pipe during cold weather.

D. Underground Location and Warning Tape: Install 6 inch wide detectable aluminum foil plastic backed tape indicating for buried water line below and installed, 12 inches to 18 inches below surface grade. Tape must be blue in color and be manufactured by Thortec or equal.

E. Tracer Wire Installation: Install 12 gauge single strand copper tracer wire to pipe with 2 inch wide PVC tape. Splicing of tracer wire shall be per manufacturer's

recommendation. The tracer wire shall run to a test station or valve box located next to a fire hydrant.

8.12 Installation Of Valves:

Valves shall be handled in such a manner as to prevent injury or damage. Valves shall be set and joined to pipe in the manner previously specified for cleaning, laying and joining mechanical and push on joints. Valves shall be set in such a manner that the valve stems are plumb. Valves shall be wrapped with polyethylene encasement material in accordance with [6.41 A](#).

Valves shall be located at the point on the main, which would be intersected by the street property line extended and as outlined in [5.10](#). Any deviations from this shall be at the discretion of Denver Water.

If so ordered by Denver Water, valves shall be operated prior to installation to ensure good operating condition.

8.13 Installation Of Valve Boxes:

A valve box shall be provided for every valve. The valve box shall not transmit shock or stress to the valve, and shall be centered and plumb over the wrench nut of the valve, with the box cover set to the elevation determined by Denver Water. It will be the responsibility of the Applicant to insure that valve boxes are plumb and raised to the proper elevation.

8.14 Installation Of Fittings:

All fittings in Denver and Total Service Areas shall be mechanical joint in compliance with [MS-3](#). Distributor Contract Areas may elect to use push on joint fittings except fire hydrant tees, which shall be mechanical joint. Fittings shall be set and joined in the manner described in 8.10.B. The use of wyes in main extensions or private pipe extensions is strictly prohibited.

Where PVC pipe is inserted into cast iron or ductile iron fittings, beveled portions of the spigots shall be removed to accommodate the expansion characteristics of the plastic to the lesser depth of bell.

All repair fittings and stainless steel repair clamps shall be wrapped with polyethylene encasement material as described in [8.24.C](#) when installed during a main repair.

8.15 Installation Of Tapping Saddles:

A tapping saddle is used to make a wet connection to an existing main without taking the main out of service. A tapping saddle and tapping valve are not a substitute for a property line valve. A valve box shall be installed with the tapping valve.

Tapping saddles may be installed side by side when specifically approved by Denver Water. A 12 inch space shall be required between adjacent saddle plates. In an intersection, two tapping saddles may be used to run lines out of both sides of the pipe if the alignment of the pipe is kept straight out of the tapping saddle. The use of two tapping saddles, either side by side or back to back, as a substitute for a cross is strictly prohibited. A 6 inch tap on a 6 inch main and an 8 inch tap on an 8 inch main will be approved, a 12 inch on a 12 inch main will not be approved.

8.16 Fire Hydrants:

A. Installation: All hydrants shall be field staked for location and grade. Final location shall be in accordance with approved drawings. Fire hydrants shall be set so that the elevation of the center of the traffic flange is 3 inches above the finished grade of the ground or top of the curb. All hydrants shall stand plumb and be installed as indicated on Sheet 7 of the [Standard Drawings](#).

Each hydrant shall be connected to the street main by a 6 inch branch line. The branch line shall be ductile iron pipe only. An independent 6 inch gate valve shall be installed on each fire hydrant branch. The valve shall be firmly anchored to either a mechanical joint tee with a 6 inch anchor coupling (also called swivel adapter or locked hydrant adapter) or to a mechanical joint anchor tee (also called swivel tee or locked hydrant tee).

The fire hydrant branch shall be anchored to the valve by means of megalugs.

Exception: When making a wet tap for a fire hydrant, a tapping valve and saddle shall be used in place of the mechanical joint tee, swivel adaptor and valve.

B. Hydrant Drainage: Drainage shall be provided at the base of the hydrant by placing rock from the bottom of the trench, to at least 12 inches above the barrel flange of the hydrant, and to a distance of 12 inches around the elbow. The minimum distance from the bottom of the trench to the bottom of the hydrant elbow shall be 6 inches. The minimum amount of rock placed shall be 1/3 cubic yard. The rock shall be a well-graded gravel, cobble, or brick size crushed rock.

C. Hydrant Protection from Corrosion: The ductile iron branch line, and fittings, from the hydrant base up to and including the tee, shall be encased in polyethylene wrap. The type of polyethylene and manner in which it is to be installed shall conform to [8.24.C](#). Bedding and pipe zone material shall be used from a point 6 inches below to a point 6 inches above the branch line. Bedding and pipe zone material shall be as specified in [7.10.B](#).

8.17 Fireline Connections:

The installation of fireline connections shall conform to Sheet 35 and 36 of the [Standard Drawings](#) and to Chapter 3. Fireline connections shall be restrained, ductile iron pipe only. The fireline connection shall have a valve 2 feet from the property line on the street side of the property line. The fireline connection shall be protected from corrosion.

Fireline connections for residential usage only are available in one inch and 2 inch sizes if approved by Denver Water. Requests for these connections must be submitted with drawings to Denver Water for approval.

8.18 Kickblocks:

The following standard shall apply to kickblocks as shown on Sheet 19 and 20 of the [Standard Drawings](#):

A. Installation: Kickblocks shall be constructed at all bends and fittings which require support due to unbalanced line thrust, and which are not restrained. Care

shall be taken not to block outlets or to cover bolts, nuts, clamps or other fittings or to make them inaccessible. A bond breaker shall be placed between the pipe and the kickblock to aid in ease of future removal. For the same reason, if a large kickblock is to be placed, it shall be separated into sections by a suitable material. Sheet 19 of the [Standard Drawings](#) show sizes and shape of kickblocks. Bearing surface areas are minimum areas to bear against the undisturbed trench wall. If, in the opinion of Denver Water, the soil bearing capacity is not sufficient to provide adequate support based on minimum bearing areas shown on the Standard Drawings, then the minimum bearing area shall be increased to a size that will ensure support restraint. In every instance, the kickblock shall bear against undisturbed earth. When it is impossible, through over excavation or other cause, to place a kickblock against undisturbed earth, restraint shall be required to anchor the fittings to the main.

Before placing concrete, equipment for mixing and transporting the concrete shall be clean. Debris, water or ice shall be removed from the place to be occupied by the concrete. Concrete shall not be placed on frozen subgrade. Concrete shall be placed only in the presence of the Inspector unless inspection has been waived prior to the placement.

B. Formwork for Kickblocks: Forming for concrete kickblocks and anchors will be done by bulkheading around the shape of the kickblock or anchor with wood, burlap sacks, or reinforced paper sacks filled with sand or earth. Sacks shall be of a size easily handled when full, and shall be left in place in the trench. Wood forms shall be removed before backfilling.

If the main must be placed immediately into service, harness rods may be used in lieu of kickblocks or wood may be used to form up kickblocks. Wood forms shall be of such design as to support the thrust until the concrete has set and shall not be considered a substitute for the concrete kickblock.

No horizontal struts or braces required for trench shoring shall remain in the concrete kickblocks. Prior to placing concrete, the forms and ditch bank shall be inspected and approved by Denver Water.

When concrete is deposited against ground without the use of forms, the ground shall be thoroughly moistened or other provisions made to prevent the ground from drawing water from the concrete.

C. Minimum Kickblock Curing Time: Newly placed concrete shall be allowed to set, undisturbed, for a minimum of 24 hours.

D. Compaction of Fill Over Kickblocks: Backfill may be placed over kickblocks once the surface has set sufficiently to resist the weight of the backfill. However, no tamping or compacting shall be allowed above the kickblock for a minimum of 24 hours after placement.

8.19 Concrete Structures:

A. Formwork: Forms shall produce shapes, lines and dimensions of the concrete structures as shown on the Drawings.

The formwork shall be designed according to the loads and allowable stresses set forth in ACI 347.

Forms may be made of wood, metal or other acceptable material approved by Denver Water. The forms shall produce a smooth concrete finish to the tolerances described in ACI 301. Form material with raised grain, torn surfaces, worn edges, patches, dents or other defects, which will impair the texture of the concrete surface, shall not be used.

Forms shall be mortar tight and braced or tied to maintain proper position and shape during and after concrete placement. Embedded metal ties with snap-off ends shall be used for internal form ties. Use of ordinary wire ties is not be allowed. Withdrawal of form ties through the walls will not be permitted.

All exposed edges shall be chamfered with a 3/4 inch, 45 degree bevel.

All surfaces of forms and embedded items shall be cleaned of all foreign material before concrete is placed. The recommendations of ACI 347 for form removal times under normal conditions shall be followed. Denver Water shall determine if additional time is required before form removal.

Forms shall be removed in a manner, which will insure the integrity of the structure and its surfaces.

B. Mixing and Placing: Equipment used in mixing and transporting concrete shall be clean. Debris, water or ice shall be removed from the places to be occupied by the concrete. Concrete shall not be placed on frozen subgrade. Wooden forms shall be thoroughly wetted (except in freezing weather) or a form release agent shall be applied.

Ready-mixed concrete shall be mixed and delivered in accordance with ASTM C 94. Water may be added one time immediately upon arrival at the job site to bring the slump within the required limits.

The concrete shall be conveyed from the mixer to the place of final deposit by methods, which will prevent separation. Equipment for chuting, pumping and conveying concrete shall be of such size and design as to ensure a continuous flow of concrete at the discharge end without separation of materials. Concrete shall not free fall a vertical distance greater than five feet during discharge into the forms.

Concrete shall be deposited as nearly as possible in its final position to avoid segregation due to handling or flowing. Concrete shall be placed at a rate such that it is, at all times, plastic and flows readily between reinforcing steel. Concrete that has partially hardened or is contaminated by foreign materials shall not be allowed.

Concrete shall be deposited continuously in layers of such thickness that no concrete will be deposited on or against concrete, which has hardened sufficiently to cause the formation of seams or planes of weakness within the area or section. Concrete shall not be placed in lifts exceeding 18 inches in thickness.

The accumulation of water on the surface of the concrete due to water gain,

segregation or other causes during placement and consolidation shall be prevented by adjustments in the mix design.

When placing concrete during cold weather as defined in ACI 306, the temperature of the concrete mix during placing shall not be lower than 55°F and all concrete work shall follow the recommended practices of ACI 306. When placing concrete during hot weather as defined in ACI 305, the temperature of the concrete mix during placing shall not be higher than 85°F and all concrete work shall follow the recommended practices of ACI 305. Cooling or warming plastic concrete mixtures shall not be undertaken without the approval of Denver Water.

C. Consolidation: All concrete immediately after depositing shall be thoroughly consolidated with internal vibrators as recommended in ACI 309. Denver Water shall approve the size, type and number of vibrators used for each concrete placement. The concrete shall be thoroughly worked around the reinforcing steel, around embedded items and into the corners of the forms. Vibrators shall be supplemented by spading, rodding or forking to eliminate all honeycomb at the form face and voids around embedded items.

D. Finishing: Where concrete surface finishes are not shown on the Drawings, unformed flat surfaces shall be screeded and wood float finished and interior floor surfaces shall be steel trowel with light broom finished to Class A tolerance in accordance with ACI 301.

No wetting of concrete surfaces during slab finishing operations shall be permitted. No concrete finishing operation shall be performed while there is water on the surface.

E. Construction and Contraction Control Joints: Construction joints not indicated on the plans must have specific approval of Denver Water. All concrete surfaces where joints are made shall be thoroughly cleaned and laitance removed prior to placing adjoining concrete. Contraction control joints shall be cut one quarter the depth of the slab. When power saw cutting methods are used, joints shall be cut as soon as the concrete surface is firm enough not to be torn or damaged by the saw blade. Water employed in cutting, washing and rinsing of concrete contraction control joints shall not stain, discolor or affect exposed surfaces of the structures, or damage the environment of the project or adjacent areas. Methods of waste water disposal shall be subject to approval by Denver Water.

F. Curing and Protection: Concrete shall be cured by a method recommended by ACI 308. When the daily mean ambient temperature is above 40°F, the finished concrete shall be cured continuously for a minimum of 7 days or for the time necessary to attain 70% of the specified compressive strength, whichever period is less. When the mean daily ambient temperature is 40°F or lower, the finished concrete shall be continually cured at a minimum temperature of 55°F for the period recommended by ACI 306 to prevent damage from early-age freezing and provide the service category strengths required for each placement.

Concrete curing on formed surfaces shall be initiated immediately after removal of

the forms or as directed by Denver Water.

Concrete curing on slabs shall be initiated immediately after the water on the surface of the slab has evaporated or as directed by Denver Water.

G. Surface Repair: Surface defects, including fins, tie holes, and honeycombed areas shall be repaired down to solid concrete in accordance with ACI 301.

8.20 Reinforcing Steel For Concrete Structures:

A. Installation: Reinforcing steel shall be accurately formed to the dimensions indicated on the plans. Bends in bars shall be made cold. Bars with kinks or bends not shown on the plans shall not be used.

Splices shall be located where shown on the plans. Splices at other locations must be approved by Denver Water. Welded wire mesh shall be lapped one space and securely wired together.

Before the reinforcement is embedded in concrete, the surfaces of the bars, and bar supports, shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease, or other foreign substances, which are objectionable. Reinforcement will be inspected for compliance with requirements as to size, shape, length, splicing position, and amount after it has been placed.

B. Placing of Reinforcing Steel: Reinforcing steel surfaces and supports shall be cleaned of flakey rust, loose mill scale, dirt, grease or other foreign substances.

Steel reinforcing bars and welded wire fabric shall be placed accurately within the forms and be well secured with annealed wire before concrete is placed. Steel reinforcing bars in walls shall be tied at a minimum of every other intersection or as directed by the Denver Water. Steel reinforcing bars in slabs shall be tied at every intersection. Steel reinforcement in slabs shall be supported on chairs of metal, plastic or concrete in a manner to prevent any steel reinforcement dislocation during slab construction.

Splices other than those shown on the Drawings shall not be constructed without the approval of Denver Water.

Reinforcing steel shall be protected by the thickness of concrete indicated on the plans. Where not otherwise shown, the thickness of concrete over the reinforcement shall be as follows:

1. Where concrete is deposited against ground without the use of forms, not less than 3 inches.
2. Where concrete is exposed to the weather, or exposed to the ground but placed in forms, not less than 2 inches for bars more than 5/8 inch diameter and 1-1/2 inches for bars 5/8 inch diameter or less.
3. In formed surfaces not in contact with the ground or exposed to the weather, not less than 3/4 inch.

8.21 Joint Restraint Devices:

Joint restraint devices shall be used at all bends and fittings where kickblocks cannot be

used due to existing field conditions or where joint restraint devices are specifically required. Joint restraint devices shall be required for the following installations:

1. Fire hydrants
2. Fireline connections
3. Three inch and larger domestic line connections
4. Vertical bends
5. Reducers
6. Vertical and horizontal offsets
7. Bends, line valves and fittings
8. 90° horizontal bends
9. Bulkheads and plugs
10. Bored casings
11. When it is not possible to place against undisturbed earth
12. When, in the opinion of Denver Water, the bearing capacity of the soil is not sufficient to provide adequate restraint

Horizontal and vertical offsets and reducers shall be restrained on each side of the fitting. For all other fittings, the length of tied pipe shall be in accordance with Sheet 21 of the [Standard Drawings](#). All joint restraint devices and appurtenances shall conform to [6.05 D](#) and Sheets 22 through 28 of the [Standard Drawings](#).

8.22 Connections To Denver Water's System:

A. Connections: Connections to Denver Water's system shall be in a neat and workmanlike manner. Denver Water shall be present at all times during the construction of the connection. The connection is subject to approval by Denver Water. Only one connection to the existing system will be permitted until the conditions and tests outlined in [8.27](#) have been met.

Denver Water does not guarantee water tightness of its valves on existing facilities. If existing valves leak, Denver Water will assist in reducing the leakage, but the Contractor shall use appropriate methods to work with the resulting leakage.

No connection will be installed or allowed by Denver Water unless the water supply is protected as required against actual or potential backflows. Water service to any premise will be discontinued by Denver Water if a backflow prevention device that is required is not installed, tested, and maintained, or if it is found that a backflow prevention device has been removed, by passed, or if an unprotected cross-connection exists on the premises. Service will not be restored until such conditions or defects are corrected.

An approved backflow prevention device shall also be installed on each service line and fireline within a licensee's water system, immediately following the meter, and in all cases, before the first branch line leading off the service line wherever

the following conditions exist:

1. In the case of premises having an auxiliary water supply which is not or may not be of safe bacteriological or chemical quality and which is not acceptable as an additional source by Denver Water, Denver Water's water system shall be protected against backflow from the premises by installing an approved backflow prevention device in the service line and fireline appropriate to the degree of hazard.
2. In the case of premises on which any industrial fluids or any other objectionable substance is handled in such a fashion as to create an actual or potential hazard to Denver Water's water system, Denver Water's system shall be protected against backflow from the premises by installing an approved backflow prevention device in the service line appropriate to the degree of hazard. This shall include the handling of process waters originating from Denver Water's system which have been subject to deterioration in quality.
3. In the case of premises having internal cross-connections that cannot be permanently corrected and controlled, or having intricate plumbing and piping arrangements or where entry to all portions of the premises is not readily accessible for inspection purposes, making it impractical or impossible to ascertain whether or not dangerous cross-connections exist, Denver Water's water system shall be protected against backflow from the premises by installing a backflow prevention device in the service line.

B. Operation of Valves: In connecting to Denver Water's system, it may be necessary to operate existing Denver Water valves. Valves on Denver Water's system that must be operated to make a connection shall be operated by the appropriate Denver Water personnel only. The Contractor shall give Denver Water 48 hours notice to arrange for operating valves. Both the Contractor and Denver Water shall be present when the valves are operated.

C. Interruption of Service: Installation of a connection that will require closing existing valves may cause an outage of water to existing Denver Water customers. Affected customers shall be notified, in writing, 24 hours in advance. The notices shall be delivered by hand to each residence. An attempt shall be made at each residence to deliver the notice personally to the occupant. If the occupant cannot be contacted, the written notice shall be left at the door. Notification must be done by the Contractor.

The appropriate fire prevention bureau for the affected area shall be notified 48 hours in advance. A description of the boundaries of the affected area, and the location of all fire hydrants in that area shall be provided to the appropriate fire prevention bureau. Notification shall be done by the Contractor.

A normal outage shall be a maximum of 8 hours. If the outage will be greater than 8 hours, the work shall be done in a manner to minimize the inconvenience to customers, such as working at night in a continuous operation until service is restored. A connection which will require an outage longer than 8 hours shall be subject to review by Denver Water as to the appropriate timing of the connection.

If in the process of installing a connection there exists an industry or building in the area that cannot be out of water, such as a hospital, appropriate means shall be taken to provide and convey water. The water and the means of conveyance shall be approved by Denver Water.

8.23 Corrosion Protection Systems:

A. *Dissimilar Materials*: Cathodic protection and insulation shall be installed as required by Denver Water. Particular care shall be taken to insulate between dissimilar materials.

B. *Insulating Joints*: Whenever it is necessary to join pipe of dissimilar metal, a method of insulating against the passage of electrical current, approved by Denver Water, shall be provided. Special care shall be exercised during the installation of these joints to prevent electrical conductivity across the joints. After the insulating joint installation is completed, Denver Water will test the joint. Should the insulated joint fail the test, it shall be removed, inspected and any necessary repairs made. The joint shall then be reinstalled and tested. This process shall continue until the joint is successfully tested. Typical insulated joints are shown on Sheet 37 of the [Standard Drawings](#) and [6.41.B](#).

C. *Polyethylene Encasement Material*: Metallic pipe, joint restraint, fittings, tie rods and appurtenances regardless of soil resistivity, shall be polyethylene encased. The polyethylene encasement shall prevent contact between the pipe and bedding material, but is not intended to be a completely airtight and watertight enclosure.

Polyethylene pipe wrap material shall be applied to line pipe in the manner shown on Sheet 38 of the [Standard Drawings](#), and [6.41](#). The polyethylene shall have a minimum thickness of 8 mils and conform to [MS-13](#). A 2 inch wide 10 mil thickness polyethylene pressure-sensitive tape shall be used to close seams or hold overlaps. Prolonged exposure to sunlight will eventually deteriorate polyethylene film. Keep exposure to sunlight to a minimum.

Before Denver Water will tap a water main, the trench, pipe and polyethylene wrapping shall be in a state of readiness. Damage to polyethylene pipe wrap in the trench prior to and during backfill shall be repaired to the satisfaction of Denver Water. Damage to the pipe wrap caused by tapping the main shall be repaired by Denver Water.

8.24 Chlorination:

All main extensions and private pipe extensions shall be chlorinated in accordance with AWWA C651, and the local health authority having jurisdiction, prior to acceptance by Denver Water. The chlorinating agent, and method of application, shall be approved by Denver Water.

The chlorination of the finished pipeline shall be done prior to the hydrostatic testing. Before filling the pipe with water, the pipe shall be clean and free of debris to the satisfaction of Denver Water. Denver Water will not provide labor or material for disinfection to Applicant's installing mains under private contract.

Chlorine tablets may be used for disinfection in 12 inch and smaller pipe. Sixteen inch and larger pipe requires a chlorine slurry fed into the water used in filling the pipe. Chlorine tablets shall be attached to the inside top of the pipe with an approved adhesive certified to NSF Standard 61 prior to the pipe installation in the trench. An approved adhesive is Dow Corning 732 Multi-Purpose Sealant.

**Number of hypochlorite tablets of 5 gram strength required
for a dose of 50 milligrams/liter***

Pipe Length (Feet)	Pipe Diameter (Inches)		
	6	8	12
13 or less	2	2	5
18	2	3	6
20	2	3	7

*Based on 3-3/4 gram available chlorine per tablet.

After the pipe is filled with water and chlorine, the chlorinated water shall be held in contact with the pipe for 24 hours. At the end of the 24 hour period, the water in the pipeline shall be tested by the local health authority or their designated representative to insure a residual chlorine content of not less than 25 milligrams per liter. Then the pipeline shall be thoroughly flushed to remove the heavily chlorinated water. Care shall be taken in flushing the pipeline to prevent property damage and danger to the public.

Samples of water will be collected for bacteriological examination and residual chlorine content testing before the pipe is put into service. Testing of residual chlorine, and sampling will be done by the local health authority or their designated representative.

8.25 Hydrostatic Testing:

No hydrostatic tests shall be made on any portion of the pipeline until field placed concrete has had adequate curing time as defined for kickblocks in [8.20.F](#).

Denver Water shall be notified 24 hours in advance of testing. **All testing shall be made in the presence of Denver Water.**

Only the following methods are acceptable for supplying potable water for hydrostatic testing:

1. Water may be taken from a nearby pressurized water source which has been previously chlorinated, tested and accepted, such as a fire hydrant.
2. Water may be delivered to the site in a chlorinated water truck having a minimum capacity of 300 gallons. The water truck shall be used exclusively for the transportation of potable water.
3. Any previously tested, chlorinated and accepted water main, which is pressurized and is to serve the new main extension may be tapped on the pressurized side of the closed valve.

In any event, the method of supplying water as well as the source of water for hydrostatic testing must be certified and approved by Denver Water. Use of barrels, sanitary or

otherwise, to supply water for hydrostatic testing is strictly prohibited.

Denver Water will furnish only the calibrated meter but not the pump for testing. The pipeline shall be properly backfilled and shall be in a state of readiness for testing. All bulkheads, pumps, taps and appurtenances necessary to fill the pipeline and maintain the required pressure shall be in place. The pipeline shall be filled with water and the test pressure of 150 pounds per square inch shall be applied to the pipeline by means of a continuously operating pump, equipped with a bypass valve for regulating pressure. When filling the pipeline, it shall be filled at a rate, which will not cause any surges, nor will it exceed the rate at which the air can be released.

All air in the line shall be properly purged. Where blowoffs or hydrants are not available or are not effective in purging air from the line, Denver Water shall require a tap to purge the line. The location and size of tap shall be at Denver Water's discretion.

While the test pressure is maintained, an examination shall be made of the pipeline in general, and any leaks shall be repaired. Any pipe or fitting found to be faulty shall be removed and replaced. No leakage is allowed through the bonnet of the line valve. Any valve leaking through the bonnet shall be repaired in place or removed and replaced. Cutting and replacing pavement, excavating and backfilling may all be necessary parts of locating and repairing leaks discovered by pressure testing of pipe.

After all visible leaks have been stopped, the full test-pressure shall be maintained for 2 continuous hours. Allowable leakage for each section between line valves shall not exceed the following leakage rates for 4 inch through 20 inch distribution and transmission mains:

Allowable Leakage		
Pipe Size (Inches)	Per 1,000 Feet of Pipe (Gallons Per Hour)	
	DI	PVC
4	.37	.33
6	.55	.50
8	.74	.66
12	1.10	1.00
16	1.47	
20	1.84	

The amount of leakage in the 24 inch and larger conduits shall be identified in project specifications.

Should testing show a leakage rate in excess of the rates shown, the pipeline shall not be accepted. The pipeline shall be repaired, rechlorinated as described in 8.25 and retested until it meets the test requirements.

8.26 Acceptance And Release For Taps:

A main shall be accepted by Denver Water and released for taps when the following conditions have been met:

A. Installation: The main and all appurtenances have been installed to the satisfaction of Denver Water and all pertinent notes and measurements have been made.

B. Tests: The following tests have been passed and notification of passing has been sent to Denver Water:

1. Chlorination test and any other test(s) required by the local health authority; see [8.24](#).
2. Compaction test performed under the direction of a Registered Professional Engineer indicating the trench backfill meets Denver Water requirements; see [7.11](#).
3. Hydrostatic test; see [8.25](#).
4. Valve and valve box inspection; see [8.13](#) for installation.

C. Location: In Denver and Total Service areas, all surface features of the water facilities have been located and documented under the supervision and responsibility of a Land Surveyor, registered in the State of Colorado, by GPS or other survey methods. Values of these features shall have a positional accuracy not to exceed three centimeters (3 cm) and will be submitted to Denver Water by acceptable electronic media. These values shall be in a coordinate system readily equated to NAD83 State Plane Coordinates, or Denver Water's Metro Grid Coordinate System. If the submittal is in a system to be converted to NAD83 State Plane Coordinates, detailed and complete instructions for conversion shall accompany the submittal. These values are intended to serve as the basis for the final "As-Built" plans of the project.

8.27 Blowoff Assembly:

In all installations where the main will be permanently deadended, such as a cul-de-sac, a blowoff assembly shall be installed. Where the main will be temporarily deadended, such as the boundary of a subdivision filing, a blowoff shall be installed, unless a fire hydrant, which can serve additionally as a blowoff, is located at the main's temporary end. The blowoff shall be installed at a right angle to the main and on the side that will allow the water to drain away from the main to the nearest gutter.

The standard required blowoff assembly for 12 inch and smaller mains shall be a 2 inch as shown on Sheet 12 of the [Standard Drawings](#). Under special conditions, such as a long run with few taps, a nonstandard blowoff larger than 2 inch may be required.

The standard required blowoff for 16 inch and larger ductile iron pipe shall be a 6 inch as shown on Sheet 13 of the [Standard Drawings](#).

8.28 Sewer Crossing:

When, during the course of installation, the main or associated piping crosses over or under a sanitary or storm sewer constructed of either vitrified clay or concrete pipe, the sewer shall be replaced or protected as shown on the plans and as described below or as otherwise directed by Denver Water.

When the sewer is 15 inches or less in diameter and crosses over the water main or associated piping, and protection is not otherwise shown on the plans, where applicable, the sewer shall be replaced with poly-wrapped Special Class 50 ductile iron pipe manufactured in accordance with AWWA C151 or Type PSM SDR 35 PVC sewer pipe manufactured in accordance with ASTM D 3034. Re-connections to the existing sewer pipe shall be made with watertight, flexible couplings approved by Denver Water and the Authority having jurisdiction over the sewer being replaced. All drains that exist under the sewer shall be restored in a manner that will prevent any flow in the drain from entering the trench in which the water main or associated piping is installed.

If the sewer is greater than 15 inches in diameter, all necessary precautions shall be taken to protect the sewer during installation of the main or associated piping. All drains that exist under the sewer shall be restored in a manner that will prevent any flow in the drain from entering the trench in which the water main or associated piping is installed.

When the water main or associated piping crosses over the sewer with less than 2-foot clear distance between the pipes, the sewer shall be encased with a minimum of 6 inches of concrete from springline to 6 inches above the top of the sewer. The encasement shall extend along the centerline of the sewer a minimum of one foot beyond the OD of the water main or associated piping at each end of the encasement.

In addition, when the water main or associated piping crosses under a sewer, the bedding material shall be replaced around the sewer to a point at least one foot above the top of the sewer pipe for sewers 15 inches in diameter and smaller and to at least springline for sewers larger than 15 inches in diameter, and thoroughly compacted and consolidated to support the sewer.

Sewers may not be cut without the express consent of the authority having jurisdiction over the sewer.

See Sheet 32 of the [Standard Drawings](#) for typical trench sections.

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 9 – 16 Inch And 20 Inch Transmission Mains

9.01 General:

Denver and regions under the contract receipt of water from Denver Water are experiencing changing trends in the design of subdivisions. New developments are now commonly designed with curved streets, only one or two access roadways and many cul-de-sacs. Water mains supplying these subdivisions often cannot be sized using the hydraulic grid system common in most of Denver. In some instances the maximum water demand within these developments is exceeding the allowable design capacity of a 12 inch distribution main but is often considerably under that of a 24 inch conduit. As a result, it has become necessary to introduce two intermediate sizes: 16 inch and 20 inch transmission mains.

9.02 Other Standards To Apply:

Chapter 9 addresses only 16 inch and 20 inch transmission mains. All standards that apply to 4 inch through 12 inch mains shall additionally apply to 16 inch and 20 inch mains along with the following requirements or exceptions. In case of conflict with any other chapter or section in these Standards, this chapter shall govern for 16 inch and 20 inch pipe.

9.03 Design Of Transmission Mains:

Sixteen inch and 20 inch water transmission mains shall be sized and designed in accordance with Chapter 5 with the following additional requirements.

A. Dual Feeds: All 16 inch and 20 inch lines shall be supplied by dual feeds unless otherwise directed by Denver Water.

B. Placement: Line valves shall be optimally placed such that service outages during repairs or construction are minimized. Generally this will require the ability to isolate and alternately supply all mains extending from the Transmission main but in no instance should the spacing between valves exceed 1,200 feet.

Twelve inch gate valves conforming to [MS-4](#) and 16 inch mechanical joint or flanged end butterfly valves conforming to [MS-5](#) shall be allowed on 16 inch transmission mains. Line valves to be used on 20 inch transmission mains shall be either 16 inch or 20 inch mechanical joint or flanged end butterfly valves.

The size and type of valve to be used shall be clearly indicated on all submitted plans.

If Denver Water requires the installation of electronic monitoring and remote operation equipment, the line valve shall be a butterfly valve with a rectangular vault housing the motor operator and telemetry equipment. Each installation will require individual approval. See [5.12](#) for the telemetry specifications.

C. Restraint System: All bends, bulkheads, and fittings which require restraint due to unbalanced line thrust shall be restrained by using both harness rods and kickblocks in accordance with Sheets 19 through 28 of the [Standard Drawings](#). All restraint requirements shall be in accordance with line size. Other restraint systems must be approved by Denver Water.

D. Headloss: The maximum design headloss for 16 inch mains is 2 feet per 1,000 feet of main. The maximum design headloss for 20 inch mains is 1-1/2 feet per 1,000 feet of main. Headloss is calculated using the maximum hour flow and using a C value of 130.

E. Blowoff Assemblies: Blowoff assemblies as shown on Sheet 13 of the [Standard Drawings](#) shall be installed at all low points in Transmission mains and wherever a Transmission main is deadended unless a fire hydrant, which can serve additionally as a blowoff, is provided at these locations.

F. Cathodic Protection: Cathodic protection requirements for transmission mains will be determined by Denver Water on an individual basis. Mains being installed in corrosive soils will be protected using methods as determined by Denver Water. This may consist of the installation of anodes, the bonding of pipe, polyethylene encasement or other requirements determined by Denver Water in addition to the requirements in [6.41](#).

G. Special Conditions: Each transmission main shall be examined individually to determine any special condition and/or requirements (e.g. air valves, pressure regulating valves, etc.).

9.04 Plans And Specifications:

Detailed plans and specifications for transmission main extensions shall be prepared for approval in accordance with [2.07](#) and shall contain a top of pipe profile showing the following additional requirements:

1. Existing ground line.
2. Official street grades where transmission mains are located beneath roadways.
3. Proposed final ground surface where transmission mains are installed within an easement and not located in a roadway.
4. The elevation of grade breaks, slope of pipe, location of bends and fittings and minimum clearances to all interference.

9.05 Material:

All pipe shall conform to [MS-1](#). Only ductile iron water pipe of Special Class 50 or better shall be used for 16 inch transmission mains. Only ductile iron water pipe of Special Class 51 or better shall be used for 20 inch transmission mains.

9.06 Installation:

Denver Water may permit the Applicant to have their own Contractor install a 16 inch or 20 inch transmission main. The Contractor must be pre-qualified by Denver Water for the installation of 16 inch and 20 inch pipe inside Denver and in Total Service Areas. As with 4 inch through 12 inch mains inside the City and County of Denver and Total Service Areas, Denver Water reserves the right to install 16 inch and 20 inch transmission mains when to do so is in the best interest of Denver Water. This determination is solely at the discretion of Denver Water and the Applicant shall pay all costs for extending mains whether installed by their Contractor or by Denver Water.

Sixteen inch and 20 inch mains present a greater danger when improperly designed or installed and the nature of their supply is more important than that of smaller mains. Denver Water will, therefore, review the design and installation of these mains more closely to insure that sound engineering and construction procedures are followed, within the context of [2.08](#).

9.07 Sewer Crossings:

The provisions of [8.29](#) shall apply to 16 inch and 20 inch transmission mains.

9.08 Easement Width Requirements:

The easement width requirements in [5.09 C](#), D, and E shall apply to the installation of 16 inch and 20 inch transmission mains with the following additional requirements.

A. Dedicated Street: The cross section of a dedicated public roadway must have as a minimum a 32 foot surfaced roadway flow line to flow line.

B. Private Roadways: The cross section of a private roadway must have as a minimum 30 feet of surfaced roadway and a 4 foot attached walk, or 34 feet of surface roadway. The easement shall have a minimum width of 34 feet.

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 10 – 24 Inch And Larger Conduits

10.01 General:

All conduits which will become part of Denver Water system shall be designed and built by Denver Water. In cases where Denver Water determines that the Conduit will not be part of its system, Denver Water may allow a Distributor to design and/or install conduits; however, Denver Water must approve the design and installation of these Conduits to insure that sound engineering and construction procedures are followed within the context of [2.08](#). The intent of this chapter is to state the additional design requirements for conduits and should not be construed as permission to design and install conduits.

Design of the conduit should proceed only after approval to design and/or construct the conduit is received from Denver Water. The overall plan, size, location, and any other pertinent details shall be reviewed by Denver Water prior to the submittal of plans and specifications required by 10.05.

The Distributor shall pay all costs in the design and construction of conduits including those incurred by Denver Water for inspection, testing of materials, and other Denver Water services.

10.02 Other Standards To Apply:

Chapter 10 addresses only conduits. All Standards that apply to 4 inch through 12 inch distribution mains and to 16 inch and 20 inch transmission mains shall apply to Conduits along with the additional requirements and exceptions stated herein. In case of conflict with any other section, this chapter shall govern for conduits.

10.03 Preliminary Investigation:

If the Distributor is allowed by Denver Water to conduct its own preliminary investigation, these requirements must be met:

A. Subsoil Investigation: A subsoil investigation shall be performed by a geotechnical engineer from exploratory holes dug to determine the bearing capacity and backfill suitability of the soil, presence of groundwater or bedrock, and any other condition which may affect the construction of the pipeline. Test holes shall be dug with a maximum spacing of 750 feet and at railroad, highway, and waterway crossings.

B. Alignment: A stationed alignment of the proposed conduit is required to define

the route with lines, angles, and curvatures referenced to land corners and other official survey control points when available. No negative stationing is allowed. The angle points, curve points and the centerline at a minimum spacing of 100 feet shall be marked on the ground, with an accuracy of at least one part in 5,000 which shall be checked by Denver Water prior to acceptance of the survey work.

All points of intersection (PI's), points of curvature (PC's), points of tangency (PT's), angle points (AP's) and any points on the tangent (POT's) needed for intervisibility shall be marked with semi-permanent steel pins in the ground such as concrete reinforcing bars, P-K nails or survey spikes.

C. Profile: A ground surface profile of the alignment in National Geodetic Survey datum tied to official survey bench marks is required. Additional semi-permanent bench marks shall be established every 1,500 feet by closed loops of Third-Order accuracy. The profile shall consist of ground surface elevations along the proposed conduit centerline at every 100-foot station and at grade breaks. All level loop and profile data shall be recorded in field books.

D. Topographical Features: Topographical features within the street or right-of-way and any topographic feature outside the right-of-way which may interfere with the operation or installation of the conduit shall be accurately shown in field books by both note and drawing. Topographic features may also be compiled by aerial photogrammetry methods.

E. Cross-Sections: In areas where the ground slope perpendicular to the centerline of the Conduit exceeds 5 percent, cross sections shall be taken at all profile points and shall extend at least 25 feet to each side of the centerline. All cross section data shall be entered into field books.

F. Utilities: All utility crossings or close utility interference shall be exposed by digging test pits. Field books shall be used to record the size, nature, and location of the interference by station offset and elevation.

G. Field Book: All survey data compiled in the determination of the route location, the extent of the interference, the centerline profile, the cross sections and level loops shall be entered into field books provided by Denver Water and submitted with the plans and specifications.

10.04 Design:

Conduits shall be designed in accordance with all other applicable sections of these Standards and the following additional requirements.

A. Line Valves: Line valves shall be placed such that service outages experienced during future repairs or construction are minimized. Generally, this will require the ability to isolate and alternately supply all mains extending from the conduit, but in no instance shall the spacing between valves exceed 2,500 feet.

Line valves shall be full line size butterfly valves with flanged end connections conforming to [MS-5](#). Precast concrete manholes shall be placed over valve operators. The valve installation shall include a tap on each side of the valve for

chlorination and/or air release. See Sheet I8 of the [Standard Drawings](#) for line valve assemblies for 24 inch and 30 inch conduits. Line valve installations for larger diameter conduits require individual approval by Denver Water.

If Denver Water requires the installation of supervisory control and data acquisition, the line valve shall be a butterfly valve with a rectangular vault housing the motor operator and telemetering equipment. Each installation will require individual approval. See [5.12](#).

B. Restraint Systems: All bends, fittings, line valves, and bulkheads shall be restrained by using both tied joints and kickblocks. Restraint systems must be approved by Denver Water. Kickblocks shall bear on undisturbed soil and have sufficient clearance from adjacent interference.

C. Headloss: The maximum design headloss for Conduits shall be one foot per 1,000 feet of pipeline, based on a Hazen-Williams C-value of 130 at the maximum hourly demand.

D. Blowoff Assemblies: Blowoff assemblies shall be installed at all low points in the conduit, wherever a conduit is deadended and at line valves where the conduit slopes toward the valve. See Sheet 13 of the [Standard Drawings](#) for blowoff installations for 16 inch and larger ductile iron pipe.

E. Cathodic Protection: Cathodic protection requirements for conduits will be determined by Denver Water on an individual basis. Conduits being installed in corrosive soils shall be protected using methods as determined by Denver Water. This may consist of the installation of anodes, the bonding of pipe, polyethylene encasement or other requirements determined by Denver Water in addition to the requirements in [6.41](#).

F. Air Valve Assemblies: Air release and vacuum valve assemblies shall be installed at high points in the conduit, where there is an abrupt change of slope and at line valves where the conduit slopes away from the valve. See Sheet 17 of the [Standard Drawings](#) and [MS-10](#) for air valve assemblies for use with 24 inch and 30 inch conduits. Air valve assemblies for larger diameter conduits require individual approval by Denver Water.

G. Access Manholes: Access manhole assemblies as shown on Sheet 17 of the [Standard Drawings](#) shall be installed at intervals not to exceed 1,000 feet unless otherwise approved. The access manhole may also contain an air valve assembly if the requirements for both can be satisfied. In some cases, closure assemblies may be substituted for access manholes. Access manholes are not required for 24 inch diameter ductile iron pipe except on each side of butterfly valves.

H. Special Conditions: The location and design of the outlets, tie-ins to any existing or proposed facilities and the bulkheads at the end of conduits must be approved by Denver Water.

Each conduit plan shall be examined individually to determine any special condition and/or requirements by Denver Water (e.g., pressure regulating valves,

telemetry, pitots, etc.).

I. Clearance: Vertical clearance between the conduit and crossing interference shall be at least one foot. Horizontal clearance shall be at least 5 feet.

10.05 Plans And Specifications:

Detailed plans and specifications for Conduits shall be prepared in accordance with [2.07](#). Plan and profile scales shall be one inch equals 50 feet horizontal and one inch equals 10 feet vertical. In addition to the requirements of Chapter 2, the plans shall contain the following information and exceptions.

A. Plan View: A plan view showing:

1. The proposed alignment of the conduit and the location of outlets, valves, blowoffs, air valves, pitots, kickblocks, bends, reducers, bulkheads, and connections to all facilities
2. All existing and proposed utilities and obstructions complete with dimensions to the conduit
3. All survey bench marks and alignment data

B. Top-of-Pipe Profile: Top-of-pipe profile showing:

1. Existing ground line
2. Official street grades where the conduit is located beneath roadways
3. Proposed final ground surface where the conduit is installed within an easement and not located in a roadway
4. The elevation of grade breaks and the slopes of the conduit
5. The elevations of all outlets, valves, blowoffs, etc.
6. The location and extent of tied joints at bends, outlets, valves, etc.
7. Any proposed or existing utility crossings of the proposed conduit complete with clearance dimensions

C. Location Map: A location map, with a list of all bench marks and field book references

D. Detail Sheet: Detail sheets showing outlets, connections, valves, etc.

E. Test Holes: The location and results of the test holes.

10.06 Materials:

A. Ductile Iron Pipe: Pipe shall conform to [MS-1](#). Ductile iron water pipe of Special Class 51 may be used for Conduits if the bedding material specified in [7.10](#) is used. Ductile iron pipe of Special Class 50 may be used for conduits if the well graded sand bedding material is compacted by jetting and vibrating to a minimum 70 percent relative density as determined by ASTM D 4253 and D 4254: The bedding and pipe zone material shall be clean, free draining well graded sand

or squeegee sand, and shall conform to the following limits when tested by means of laboratory sieves:

Well Graded Sand

Sieve Size	Total Percent Passing by Weight
3/8 inch	100
No. 4	70-100
No. 8	36- 93
No. 16	20- 80
No. 30	8- 65
No. 50	2- 30
No. 100	1- 10
No. 200	0- 3

Squeegee Sand

Sieve Size	Total Percent Passing by Weight
3/8 inch	100
No. 200	0-3

Prior to construction, the Contractor shall submit for approval by Denver Water the manufacturer's detailed shop drawings, design calculations, lists and availability of materials, and the laying schedule and marking diagram.

B. Other Pipe Materials: Conduits may be of steel or concrete if specifically approved by Denver Water. The design criteria for steel and concrete pipe shall be those currently specified by Denver Water for conduits.

10.07 Installation:

Denver Water may permit the Distributor to have their own Contractor install a Conduit. Denver Water reserves the right to install Conduits when to do so is in the best interest of Denver Water. This determination is solely at the discretion of Denver Water and the Distributor shall pay all installation costs, whether installed by their Contractor or by Denver Water.

Denver Water requires that the conduit installation be witnessed and controlled by Denver Water at the expense of the Distributor. The Distributor shall also furnish, at their own expense, such labor as may be required by Denver Water to enable thorough inspection and culling of all the materials by him and shall furnish reasonable samples of materials at the job to afford adequate testing.

10.08 Sewer Crossings:

The provisions of [8.29](#) shall apply to 24 inch and larger conduits.

10.09 As-Constructed Drawings:

The plan, profile and detail drawings shall be modified to reflect any changes in the

design. The final as-constructed drawing shall be submitted to Denver Water.

10.10 Easement Width Requirements:

The easement width requirements in Chapter 5 and 9 do not apply to the installation conduits. The adequacy of the width and alignment of dedicated public road easement and Denver Water easement shall be determined on an individual basis by Denver Water.

*Engineering Standards - Chapter 10:
Revised 07-04, Previous Revision 05-02
End*

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 11 – Recycled Water System

11.01 General:

The purpose of this chapter is to provide guidelines for planning, designing, constructing, and operating the recycled water system providing water to Denver Water customers within Denver Water's Service Area. These Standards apply to all recycled water facilities under the control of Denver Water. If in conflict with regulations promulgated by the State of Colorado acting through the Colorado Department of Public Health and Environment Water Quality Control Division (CDPHE), the State Regulations shall take precedence over these Standards.

11.02 Other Standards To Apply:

All standards that apply to 4 inch through 12 inch distribution mains, and to 16 inch and 20 inch transmission mains, and 24 inch and larger conduits including meters, valves, service line and backflow prevention and easements shall apply to recycled water systems along with the supplemental requirement and exceptions stated herein. In case of conflict with any other Section, this chapter shall govern for recycled water.

11.03 Water Quality:

All recycled water leaving the recycled water treatment plant shall conform to the water quality regulations established by CDPHE through its Water Quality Control Division. Denver Water shall maintain a system of records for water quality analyses performed on recycled water. These analyses will confirm compliance with all water quality regulations.

11.04 Potable Water Backup:

The decision to connect the potable and recycled water systems will be made at the sole discretion of Denver Water. If recycled water is unavailable due to a system malfunction or other reason, potable water may be substituted as a backup only by Denver Water. Lack of adequate recycled supply, shall not be a reason for connection to a potable source. Backup for individual customers will not be provided. Whenever a connection is made between the two systems by Denver Water, the potable water system shall be protected through the use of an approved Denver Water backflow prevention device.

11.05 Conversion From A Potable To A Recycled Line:

All facilities converted from a potable water supply to a recycled water supply shall conform to Denver Water's construction standards.

11.06 Protection Of The Potable Water System:

The potable water system shall be protected from contamination with recycled water through the physical separation of the two systems, which will be inspected by Denver Water.

All premises served with both potable and recycled water shall have installed an approved Denver Water reduced pressure backflow (RPZ) prevention device on the potable water line where it enters the facility. The use of a double check valve assembly or other backflow prevention device is prohibited. All premises that contain a recycled water system shall install an approved Denver Water air gap backflow protection system or a reduced pressure zone backflow prevention device on the potable water line.

11.07 Discharges From The System:

Discharges from blowoff assemblies, or other appurtenances on the recycled water system shall either be contained or discharged in a manner approved by Denver Water and CDPHE. Discharging into a watercourse not specifically approved by Denver Water and CDPHE.

11.08 User Permits:

Connections to the recycled water system can only be made after applying for and obtaining a Water Supply License from Water Sales of Denver Water. The license shall be issued in accordance with Denver Water policy and subject to any required approval by the Colorado Department of Public Health and Environment.

11.09 Separation From Sewer Lines:

Recycled water mains running parallel to a sanitary or storm sewer shall maintain a minimum separation of 10-feet horizontally and one-foot vertically. The elevation of the recycled line shall be above the elevation of the sewer line.

11.10 Separation From Potable Water Lines:

Recycled water lines shall cross a minimum of one-foot below potable water lines. Recycled water transmission lines parallel to potable water lines shall be installed at a minimum distance of 10-feet horizontally and one-foot vertically below the potable water line. Any deviation from these requirements will need to be approved by Denver Water. Common trench construction is prohibited.

11.11 Recycled Water Conduits:

Recycled water conduits are 24 inch diameter and larger mains carrying recycled water.

It is the policy of Denver Water to design and install 24 inch diameter and larger conduits to ensure a high quality, uninterrupted, low maintenance water service system and when it is in the best interest of Denver Water. All conduits which will become part of Denver Water's recycled water system will be designed and constructed by Denver Water. In cases where Denver Water determines that the conduit will not be part of its system, Denver Water may allow a Recycled Customer to design and/or install conduits; however, Denver Water must approve the design and installation of these conduits to ensure that sound engineering and construction procedures are followed within the context of Denver Water's Engineering Standards.

Design of the conduit should proceed only after approval to design and/or construct the conduit is received from Denver Water. The concept, size, location, and any other pertinent details shall be reviewed by Denver Water prior to the submittal of plans and specifications in accordance with Denver Water's Engineering Standards.

Design and construction of conduits carrying recycled water shall be in accordance with the recycled water and appropriate potable sections of Denver Water's Engineering Standards and following supplementary requirements:

A. Piping in the recycled water system shall be identified by an integral Pantone 2577U in color and an embossed or integrally stamped warning reading "**Caution: Recycled Water – Do Not Drink**". The printing shall be continuous on both sides of the pipe.

As an acceptable alternative, the ductile iron pipe shall be wrapped in purple polywrap and steel pipe shall have a purple polyurethane exterior or purple tape wrap exterior. Cathodic protection approved by Denver Water is required. Identification tapes also needed shall be black printing on a purple field and contain the warning stated above. The warning tape shall be a minimum of 3 inches wide.

Identification tapes shall be installed one foot above the top of the pipe longitudinally and shall be centered.

B. Valve boxes in the recycled water system shall be fitted with triangular lids cast with the words "**DMWW Recycled**". The covers shall be coated with epoxy coating, Pantone 2577U in color.

C. Valves in the recycled water system shall open in a counter-clockwise direction. Valves or valve operators located in vaults shall be tagged as belonging to the recycled water system and shall be coated with epoxy, Pantone 2577U in color.

D. Appurtenances located in vaults, including valves, valve operators, air-vacuum relief valves, blowoffs and meters shall be coated with epoxy, Pantone 2577U in color and labeled as belonging to the recycled water system. The labels shall be inert plastic formulated for prolonged exposure and shall be prepared with black printing on a white field having the words "**Recycled Water Facilities**". The minimum height of the letters shall be 1/2 inch. The labels shall be attached with heavy duty nylon fasteners.

E. Manhole covers in the recycled water system shall be fitted with covers cast with the words "**DMWW Recycled**", the covers shall be coated with epoxy, Pantone 2577U in color.

F. Cement-mortar lining of pipe shall not be allowed.

G. Six inch minimum diameter blowoff valves shall be installed on dead-end mains.

H. HDPE fiberoptic conduit shall be installed parallel to conduits as specified by Denver Water. This location is generally 3-feet off the centerline of the pipe and 3-

feet deep. Hand hole spacing shall be determined by Denver Water. Tracer wire is required for non-metallic pipe.

11.12 Recycled Water Transmission Mains:

Recycled water transmission mains are either 16- or 20 inch diameter mains.

Design and construction of transmission mains carrying recycled water shall be in accordance with the recycled water and appropriate potable sections of Denver Water's Engineering Standards and following supplementary requirements:

A. All piping in the recycled water system shall be identified by an integral Pantone 2577U in color and an embossed or integrally stamped warning reading "**Caution: Recycled Water – Do Not Drink**". The printing shall be continuous on both sides of the pipe.

As an acceptable alternative, the ductile iron pipe shall be wrapped in purple polywrap and steel pipe shall have a purple polyurethane exterior or purple tape wrap exterior. Cathodic protection approved by Denver Water is required. Identification tapes also needed shall be black printing on a purple field and contain the warning stated above. The warning tape shall be a minimum of 3 inches wide.

Identification tapes shall be installed one foot above the top of the pipe longitudinally and shall be centered.

B. Valve boxes in the recycled water system shall be fitted with triangular covers cast with the words "**DMWW Recycled**". The covers shall be coated with epoxy coating, Pantone 2577U in color.

C. Valves in the recycled water system shall open in a counter-clockwise direction. Valves or valve operators located in vaults shall be tagged as belonging to the recycled water system and shall be epoxy, Pantone 2577U in color.

D. Appurtenances located in vaults, including valves, valve operators, air-vacuum relief valves, blowoffs and meters shall painted Pantone 2577U in color and labeled belonging to the recycled water system. The labels shall be inert plastic formulated for prolonged exposure and shall be prepared with black printing on a white field having the words "**Recycled Water Facilities**". The minimum height of the letters shall be 1/2 inch. The labels shall be attached with heavy duty nylon fasteners.

E. Manhole covers in the recycled water system shall be fitted with covers cast with the words "**DMWW Recycled**", the covers shall be coated with epoxy, Pantone 2577U in color.

F. Cement-mortar lining of pipe shall not be allowed.

G. Blowoff valves shall be installed on dead-end mains and sized to allow a minimum of 2.5 fps in the transmission main.

Recycled Water Customers shall pay all costs in the design and construction of

transmission mains including those incurred by Denver Water for reviewing, inspecting, testing of materials, and other Denver Water services.

11.13 Recycled Water Distribution Mains:

Recycled water distribution mains are either 4 inch, 6 inch, 8 inch or 12 inch diameter installed in the recycled water distribution systems.

Design and construction of distribution mains carrying recycled water shall be in accordance with the recycled water standards and appropriate potable sections of Denver Water's Engineering Standards and following supplementary requirements:

A. Piping in the recycled water system shall be identified by an integral Pantone 2577U in color and an embossed or integrally stamped warning reading "**Caution: Recycled Water – Do Not Drink**". The printing shall be continuous on both sides of the pipe.

As an acceptable alternative, the pipe may be installed with a continuous purple identification tape or purple polyethylene vinyl wrap. Identification tapes shall be black printing on a purple field and contain the warning stated above. The warning tape shall be a minimum of 3 inches wide.

Identification tapes shall be installed one-foot above the top of the pipe longitudinally and shall be centered. The identification tape shall be continuous in its coverage of the pipe and shall be fastened to each pipe with plastic adhesive tape banded around the pipe. Taping attached to sections of pipe before placement in the trench shall have flaps sufficient for continuous coverage.

B. Valve boxes in the recycled water system shall be fitted triangular with covers cast with the words "**DMWW Recycled**". The covers shall be coated with a fusion bonded epoxy coating, Pantone 2577U in color. Both the top and bottom surfaces of the cover shall be coated.

C. Valves in the recycled water system shall open in a counter-clockwise direction. Valves or valve operators located in vaults shall be tagged as belonging to the recycled water system and shall be coated with epoxy and painted Pantone 2577U in color.

D. Appurtenances located in vaults, including valves, valve operators, air-vacuum relief valves, blowoffs and meters shall painted Pantone 2577U in color and labeled as belonging to the recycled water system. The labels shall be inert plastic formulated for prolonged exposure and shall be prepared with black printing on a white field having the words "**Recycled Water Facilities**". The minimum height of the letters shall be 1/2 inch. The labels shall be attached with heavy duty nylon fasteners.

E. Manhole covers in the recycled water system shall be fitted with covers cast with the words "**DMWW Recycled**", the covers shall be coated with epoxy, Pantone 2577U in color.

F. Line valves shall be spaced no more than 1,000 feet apart.

G. Cement-mortar lining of pipe shall not be allowed.

H. Blowoff valves shall be installed on dead-end mains and sized to allow a minimum of 2.5 fps in the distribution main.

The Recycled Water Customers shall pay all costs in the design and construction of distribution mains including those incurred by Denver Water for reviewing, inspecting, testing of materials, and other Denver Water services.

11.14 Recycled Water Service Lines And Appurtenances:

Recycled water service lines are for conveying water from mains to the plumbing of licensed premises by service lines and their appurtenances.

Design and construction of service lines and appurtenances carrying recycled water shall be in accordance with the recycled water standards and appropriate potable sections of Denver Water's Engineering Standards and the following supplementary requirements:

A. Service lines conveying recycled water shall be placed in a trench separate from the potable water service trench and the sanitary sewer trench. A minimum separation of 10 horizontal feet and one vertical foot shall be maintained between the recycled service line and the potable water elevation above that of the sanitary sewer and below that of the potable water line.

B. As a condition of being issued a license to use recycled water, Denver Water shall require the installation of signs at the point of use and a commitment from the user that hose bibb connections will not be installed in the user facilities or quick couplers shall be used if hose connections are necessary. Fittings shall be such that interconnection cannot be made between potable and recycled systems, nor shall hoses be interchanged between them. Signs shall be used to identify the recycled water quick coupling connections.

C. Covers for curb stop boxes and meter pits in the recycled water system shall be cast with the words "**Recycled Water**". The covers shall be coated with a fusion bonded epoxy, Pantone 2577U in color and painted top and bottom. Four inch roadway type covers shall be used.

D. Type of meters and strainers used in the recycled water system shall be approved by Denver Water's Meter Shop prior to installation. They shall be coated with epoxy, Pantone 2577U in color. The location and type shall be approved by Denver Water .

E. Meters and control valves may be installed in the same vault per Denver Water approval. Vaults shall have locking, metal door-type hatches coated Pantone 2577U in color.

F. Recycled service lines shall be required to have purple identification tape one-foot above service line stating "**Caution: Recycled Water - Do Not Drink**". The warning tape shall be a minimum of 3 inches wide.

G. Irrigation sprinklers used in on-site recycled systems shall have an exposed

surface colored purple to associate them with recycled water use. The exposed surface may be colored purple through the use of dyed plastic or rubber, or weatherproof paint. Sprinklers unable to meet these specifications shall be identified with purple recycled warning tags.

H. All on-site recycled facilities shall have restricted public access so that the general public cannot draw water from the system. Facilities, such as wash down hydrants, blowoff hydrants, blowoffs on strainers and other such facilities shall be restricted from public access. These facilities, both above and below grade, shall be housed in an approved locking container colored purple. A sign with black lettering on a purple field reading "**Caution: Recycled Water - Do Not Drink**" shall be installed on the container. Its size must be approved by Denver Water.

I. On-site recycled pumping and storage systems are not allowed except as approved and systems permitted by Denver Water.

J. Service piping in the recycled water system shall be spirally wrapped with warning tape reading "**Caution: Recycled Water - Do Not Drink.**"

K. Backflow prevention devices may be required on recycled systems if there is a risk of damage to the system or potential water quality concerns as determined by Denver Water.

The Recycled Water Customers shall pay all costs in the design and construction of service lines including tap fees and those incurred by Denver Water for reviewing, inspecting, testing of materials, and other Denver Water services.

11.15 Recycled Customers Guidelines:

A Recycled Customer must comply with any applicable State and Local regulations regarding the use of recycled water including CDPHE Regulation 84. Additionally, the following guidelines for using recycled water are presented:

A. The Recycled Customer shall designate an on-site supervisor who will be responsible for maintaining compliance with all regulations regarding the use of recycled water.

B. The Recycled Customer shall prepare and keep current record drawings showing all recycled water facilities and make them available to Denver Water. This shall include but not be limited to the location of all piping, valves, backflow prevention devices and system controllers. Also, a record of the operation schedules for each system controller shall be maintained. A copy of the appropriate operation schedule and area of coverage shall be included in each controller box in a waterproof container.

C. Denver Water will assign and the customer will adhere to a specific watering schedule.

D. The Recycled Customer must adjust and maintain the adjustment of all irrigation spray heads to eliminate over spray. This includes, but is not limited to

sidewalks, streets or public areas. Food preparation, drinking fountains and picnic areas must also be protected from overspray or windblown spray.

E. System operation shall be adjusted to minimize pooling, ponding or excessive runoff.

F. The Recycled Customer shall monitor and maintain the on-site recycled system to mitigate uncontrolled releases of water. Leaking pipes, broken sprinkler heads and unreliable valves shall be repaired immediately.

G. The Recycled Customer shall educate all maintenance personnel of the presence of recycled water and of the safety practices that must be followed when working with a recycled water supply.

H. The Recycled Customer shall obtain prior approval for proposed changes or modifications to any on-site facilities that may impact Denver Water facilities. Changes to facilities must be in compliance with CDPHE Regulation 84 and made available to Denver Water for review.

I. The Recycled Customer shall install signs or label in the areas irrigated with recycled water indicating that recycled water is being used. The signs shall contain black lettering on a purple field with the words "**Caution: Recycled Water - Do Not Drink**".

J. Signs at locations where Recycled Water is used: In all locations where Denver Water serves Recycled Water to a customer, signs in the dominant language(s) expected to be spoken at the site shall be posted. Signs shall read, "**Do Not Drink From The Sprinklers! We Use Nonpotable Recycled Water For Irrigation,**" or "**Do Not Drink – Nonpotable Recycled Water Used For Irrigation**" or similar language approved by Denver Water.

1. Where recycled water is used for industrial or commercial uses, there shall be one sign near any vault or valve that provides recycled water or access to recycled water piping. Each sign shall be at least 12" X 15".

2. Where recycled water is used for irrigation at a park, school yard or similar area, there shall be one sign at each parking lot or surfaced entry (vehicular or pedestrian) to the area. There shall also be one sign for every 5,000 feet of perimeter of the area. There shall be at least one sign per area. A single sign may be used to fulfill more than one of these requirements. Each sign shall be at least 12" x 15".

3. Where recycled water is used for irrigation at a golf course, there shall be one sign each at the first and tenth tees, near entrances to any driving ranges, and near any practice putting greens. Each sign shall be at least 12" x 15".

The Recycled Water Customer shall ensure that the on-site recycled water facilities remain in compliance with regulations promulgated by the State of Colorado and the guidelines established by Denver Water. Failure to comply with any of the standards or guidelines may result in the termination of service until the appropriate corrective steps

have been taken.

Engineering Standards - Chapter 11:
Revised 07-04, Previous Revision 05-02
End

The Board Of Water Commissioners Denver Water

Engineering Standards Chapter 12 – Integrated Water System

12.01 General:

An Integrated Water System is defined by state regulation as two or more public water systems, one of which is a supply system, whose distribution systems are physically connected and are being operated using a common set of standards for the purposes of maintaining and protecting drinking water quality. Denver Water's goal is to treat all Distributors and their customers as part of an Integrated Water System. However, in order to be included in Denver Water's Integrated Water System, a Distributor must have a Total Service Contract, or must satisfy Denver Water's Operating Rules and these Engineering Standards. A Distributor who fails to maintain its water distribution system in accordance with these Engineering Standards may be designated as a Consecutive System and will be responsible for meeting water quality testing and reporting requirements.

These standards apply inside the City and County of Denver and throughout the areas served under Total Service contracts. These standards also apply to those Master Meter and Read and Bill Distributors that are classified as part of the Integrated Water System by Water Sales.

These standards emphasize planned/preventive maintenance to avoid water quality problems, but by themselves do not guarantee compliance with State of Colorado and Federal regulations.

12.02 Maintenance Programs:

Denver Water's Operations and Maintenance Division will establish a Standard Operating Procedure (SOP) for each of the following:

- A. Valve Inspections/Closed Boundary Valves**
- B. Flushing and Testing of Dead Ends/Blowoffs**
- C. Flushing and Testing of Dead Ends/Hydrants**
- D. Valve Inspections/12 inch and Larger**
- E. Valve Inspections/12 inch and Smaller**
- F. Valve Inspections/Pressure Regulating Valves**

- G. Hydrant Inspection and Maintenance**
- H. Treated Water Storage Tank Operation**
- I. Treated Water Storage Tank Maintenance**
- J. Clear Water Storage Basins/Emergency Maintenance**
- K. Bacteriological Analysis/Total Coliform Sample Collection**
- L. Conduit Chlorination Procedure**
- M. Conduit Dechlorination Procedure**
- N. Sprayer Application Method**

Each SOP includes the purpose, policy, equipment and procedures developed by Denver Water for the operation, maintenance and quality assurance required for the Integrated Water System.

The Standard Operating Procedures can be obtained by those demonstrating a valid need by contacting the Superintendent of Water Control, Denver Water.

12.03 Distribution System Sampling:

Denver Water will be responsible for all monitoring within the Integrated Water System necessary to comply with the Safe Drinking Water Act (SDWA). Quality data will be reported by Denver Water for the Integrated Water System under one PWSID.

12.04 On-Line Water Quality Monitoring:

In critical areas of the Integrated Water System, Denver Water will require on-line monitors capable of transmitting data regarding pH, specific conductance, chlorine residual and turbidity. The sites may include reservoirs, pump stations or other appropriate locations. Denver Water will be responsible for the ownership, operation and maintenance of the monitors. Data will be telemetered to Denver Water's Load Control Operations Center, compiled and made available through the Internet. Internet data will be updated every 24 hours.

12.05 Water Quality Compliants And Communication:

A. Denver and Total Service Areas:

Denver Water and the Total Service Distributor have equal concern for water quality to the customer. Complaints received by either should be communicated immediately to the other including clarification as to the entity responsible for initial response.

Water quality issues and complaints during business hours will be directed to Denver's Water Quality Lab. Water Quality personnel will respond within Denver and Total Service areas. They will identify the problem and, along with Water Control personnel, correct the problem as promptly as possible.

After business hours, water quality issues and complaints will be directed to Water Control's Emergency Services Dispatcher. Depending on the severity of the

matter, Water Control's Dispatcher may notify the Water Quality employee on duty. Designated personnel will respond, identify the problem, and correct the problem as promptly as possible.

Data management and compliance reporting are the responsibility of the Water Quality Section.

B. Master Meter and Read and Bill Areas:

Those Master Meter and Read and Bill areas classified as part of the Integrated Water System will have responsibility for initial response, investigation and remediation of all water quality issues and complaints. The Distributor must advise Denver Water of findings and response actions.

Should the Distributor's initial response fail to achieve the necessary results, Denver Water may be called in to assist.

Any water quality complaints in the Integrated Water System service area reported to the State shall be directed to Denver Water, and Denver Water, as appropriate, will pass them on to the Distributor. Denver Water will report findings back to CDPHE. In all cases, Denver will act as the clearinghouse for water quality information.

12.06 Facility Operation And Status:

Using GIS, SCADA and appropriate methods, Denver Water will maintain a current status of all distribution system facilities and related operations. Denver Water will make the information available to the Distributors on the Internet.

Each Read and Bill and Master Meter Distributor will be responsible for maintaining a database of operation and maintenance information specific to their individual areas. Distributors will make the information available to Denver Water on an as needed basis.

12.07 Reporting Compliance:

Denver Water will be responsible for reporting compliance within the Integrated Water System. For State and Federal reporting purposes, violations within the Integrated Water System will be assigned to Denver's PSWID Number 116001.

Distributors classified as Consecutive Systems either have or will be assigned their own PWSID number. For State and Federal reporting purposes, violations will be assigned to the Consecutive Distributor's PSWID number.

The Standard Operating Procedures can be obtained, by those demonstrating a valid need, from the Superintendent of Water Control, Denver Water.

Note: Distribution System Discharges

Please be advised that some activities involve the discharge of potable water to the environment. Denver Water has been working with the State to address various compliance issues with these discharges. The outcome of these discussions is still uncertain. However, it is conceivable that activities such as reservoir draining, reservoir cleaning and flushing could require a permit from the State. Once these discussions are complete, Denver Water is planning to incorporate any permit requirements (i.e., Best Management Practices) into Denver Water's Operating Standards.

Engineering Standards - Chapter 12:
Revised 07-04, Previous Revision 05-02
End

Table Of Contents

Materials Specifications

Disclaimer and Scope of Applicability

The Engineering Standards set forth herein are prepared for and are applicable ***only*** in those water service areas served by Denver Water.


You can download complete [Engineering Standards](#), [Materials Specifications](#), or the [Standard Drawings](#) in PDF format. Each document is between 1-3 Megs.


Section	Title
MS-1	Ductile Iron Pipe
MS-2	Polyvinyl Chloride (PVC) Pressure Pipe
MS-3	Ductile Iron and Cast Iron Waterworks Fittings
MS-4	Double-Disc Gate Valves
MS-4A	Resilient Seat Gate Valves
MS-5	Flanged Rubber Seated Butterfly Valves
MS-6	Swing Check Valves
MS-7	Tapping Valves - Mechanical Joint Type
MS-8	Fabricated Steel Tapping Sleeves
MS-9	Pressure Regulating Valves
MS-10	One Inch Through 4 Inch Combination Air- Release and -Vacuum Valves
MS-11	6 inch Valve Boxes
MS-12	Dry-Barrel Fire Hydrants
MS-13	Polyethylene Encasement Material
MS-14	Magnetic Drive Displacement Type Water Meters – 5/8 inch through One inch - Frost Proof
MS-15	Magnetic Drive Displacement Type Water Meters – 1-1/2 inch and 2 inch
MS-16	Magnetic Drive Compound Water Meters – 3 inch through 6 inch
MS-17	Magnetic Drive Turbine Type Water Meters – 3 inch Through 16 inch
MS-17A	Magnetic Drive Turbine Type Water Meters – 1-1/2 Inch and 2 inch
MS-17B	Magnetic Drive Fire Service Type Water Meters – 3 inch Through 10 inch Turbine Type
MS-18	Normal Weight and Precast Concrete


<u>MS-19</u>	<u>Controlled Low Strength Backfill (CLSM)</u>
<u>MS-20</u>	<u>Concrete Reinforcement</u>
<u>MS-21</u>	<u>Brass and Bronze Goods</u>
<u>MS-22</u>	<u>Miscellaneous Items</u>
<u>MS-23</u>	<u>Meter Pit Domes and Covers</u>
<u>MS-24</u>	<u>Electric Pump Motors</u>
<u>MS-25</u>	<u>In-Line Strainers</u>
<u>MS-26</u>	<u>Concrete Vaults</u>
<u>MS-27</u>	<u>Mechanical Joint Restraint</u>
<u>MS-28</u>	<u>Bolted Sleeve Type Couplings</u>
<u>MS-29</u>	<u>Supervisory Control and Data Acquisition (SCADA)</u>
<u>MS-30</u>	<u>Fire Hydrant Meters</u>
<u>Appendix A</u>	<u>Procedure for Evaluation of Materials</u>

Standard Drawings Denver Water

Effective 12/01/2004

 You can download complete [Engineering Standards](#), [Materials Specifications](#), or the [Standard Drawings](#) in PDF format. Each document is between 1-3 Megs.

 If you wish to obtain an Engineering Standard book with CAD details, they are available at Denver Water, 1600 W. 12th Ave., 3rd Floor Engineering, Denver, CO 80204, from [Terri Steele](#) at 303-628-6604. The cost is \$100.00.

 **Attention CAD application users: All Cad files are in AutoCAD 2002 format.**
If a CAD drawing does not open after clicking the link, you can save the drawing locally by right clicking the link and selecting 'Save target as'. All of the CAD drawings on this site use the color/pen width chart here – [Attachment A](#) – to conform to Denver Water's standards for plotting. Please change the pen width values in AutoCAD accordingly, when plotting out any of the Engineering Standards drawings.

Note: These drawings are provided for standardization purposes only. They represent minimum design standards which may require upgrading for specific applications.

Standard Drawings	Formats	
	PDF	CAD
Water Distribution System Typical Plan	No. 1	No. 1
Typical Street Cross Section & Street Centerline Profile	No. 2	No. 2
Typical Street Cross Section Public Street	No. 3	No. 3
Typical Street Cross Section Private Street	No. 4	No. 4
Water Distribution System Typical Plan for Curved Streets	No. 5	No. 5
Water Distribution System Typical Plan for Cul-de-Sacs	No. 6	No. 6
Plan, Profile & Locations for Fire Hydrants, Mains, & Valves	No. 7	No. 7

Piping at Street Intersections – Future Connections	<u>No. 8</u>	<u>No. 8</u>
Typical Quarter Section Hydraulic Grid System	<u>No. 9</u>	<u>No. 9</u>
Typical Trench Section – Pipe Protection	<u>No.10</u>	<u>No.10</u>
Typical Trench Section for Pipelines in Dipping Bedrock	<u>No.11</u>	<u>No.11</u>
Blowoff Installation for 12" & Smaller Pipe	<u>No.12</u>	<u>No.12</u>
Transmission Main Blowoff Installation	<u>No.13</u>	<u>No.13</u>
Detail Permanent 2" Blowoff in 48" Manhole	<u>No.14</u>	<u>No.14</u>
Valve Box Support Plate & Valve Operator Extension Guide	<u>No.15</u>	<u>No.15</u>
2" Air Valve Assembly	<u>No.16</u>	<u>No.16</u>
Air Valve Assembly with Access Manhole	<u>No.17</u>	<u>No.17</u>
Conduit Or Transmission Main, Mechanical Joint Or Flanged Butterfly Valve Installation	<u>No.18</u>	<u>No.18</u>
Concrete Kickblocks – Bearing Surfaces & Installation	<u>No.19</u>	<u>No.19</u>
Concrete Kickblock	<u>No.20</u>	<u>No.20</u>
Length Of Restrained Pipe	<u>No.21</u>	<u>No.21</u>
Tie Rod & Washer Details	<u>No.22</u>	<u>No.22</u>
Tie Rod Coupling	<u>No.23</u>	<u>No.23</u>
Flange Lug Detail	<u>No.24</u>	<u>No.24</u>
Clamp Details & Dimensions for Use with CI & DI Fittings Only	<u>No.25</u>	<u>No.25</u>
Combination Flanged Harness Lug Details	<u>No.26</u>	<u>No.26</u>
Mechanical Joint Restraint Details	<u>No.27</u>	<u>No.27</u>
Joint Restraint Detail	<u>No.28</u>	<u>No.28</u>
Bored Crossings Beneath Conduits	<u>No.29</u>	<u>No.29</u>
Bore Casing Details	<u>No.30</u>	<u>No.30</u>
Open Cut Crossing Beneath Conduit or Conflicting Utility	<u>No.31</u>	<u>No.31</u>
Crossing Storm & Sanitary Sewers	<u>No.32</u>	<u>No.32</u>
Reference Post Typical Detail	<u>No.33</u>	<u>No.33</u>
Typical Cutoff Wall for Ditch Or Canal Crossing	<u>No.34</u>	<u>No.34</u>

2" & Larger Domestic & Fireline Connections	<u>No.35</u>	<u>No.35</u>
Fireline Connections with Domestic Service Tee	<u>No.36</u>	<u>No.36</u>
Insulated Joints, Rods, & Bolted Sleeve Type Couplings	<u>No.37</u>	<u>No.37</u>
Polyethylene Wrap	<u>No.38</u>	<u>No.38</u>
Adjustable Steel Pipe Valve Support	<u>No.39</u>	<u>No.39</u>
Industrial Vent Assembly – Installation & Details	<u>No.40</u>	<u>No.40</u>
Industrial Vent Assembly – Vent Screen	<u>No.41</u>	<u>No.41</u>
Residential Vent Assembly	<u>No.42</u>	<u>No.42</u>
Pressure Regulating Valve – Manhole Installation Typical Plan	<u>No.43</u>	<u>No.43</u>
Pressure Regulating Valve – Manhole Installation Cross Section	<u>No.44</u>	<u>No.44</u>
Pressure Regulating Valve – Rectangular Vault Typical Plan	<u>No.45</u>	<u>No.45</u>
Pressure Regulating Valve – Rectangular Cross Section	<u>No.46</u>	<u>No.46</u>
General Meter Notes	<u>No.47</u>	<u>No.47</u>
Service Line, Stop Box & Outside Meter Installation	<u>No.48</u>	<u>No.48</u>
Outside Setting for 5/8-Inch x 3/4-Inch, 3/4-Inch & 1-Inch Meters	<u>No.49</u>	<u>No.49</u>
Service Line, Stop Box & Inside Meter Installation for 3/4-Inch & 1-Inch Meters	<u>No.50</u>	<u>No.50</u>
Typical Inside Setting for 3/4" and 1" Meter with AMR	<u>No.51</u>	<u>No.51</u>
Typical Inside Setting for 3/4" and 1" Meter with AMR	<u>No.52</u>	<u>No.52</u>
Inside Meter Setting and Remote ERT Installation for Home Built on Slab	<u>No.53</u>	<u>No.53</u>
Meter Pit with Remote ERT Installation on Outside Building Wall	<u>No.54</u>	<u>No.54</u>
Outside Setting for 1-1/2" & 2" Meter with Check Valve & Bypass in Manhole	<u>No.55</u>	<u>No.55</u>
Inside Setting for 1-1/2" & 2" Meter with Check Valve & Bypass	<u>No.56</u>	<u>No.56</u>
Wall Plates & Body Clamps for 3" Meters	<u>No.57</u>	<u>No.57</u>
Wall Plates for 4", 6", 8", and 10" Meters	<u>No.58</u>	<u>No.58</u>

Inside Setting for 3" & Larger Compound Meter	<u>No.59</u>	<u>No.59</u>
Compound Meter with Both Check Valve & Bypass	<u>No.60</u>	<u>No.60</u>
Compound Meter Dimensions	<u>No.61</u>	<u>No.61</u>
Compact Fireline Meter with Bypass	<u>No.62</u>	<u>No.62</u>
Compact Fireline Meter Dimensions	<u>No.63</u>	<u>No.63</u>
Instrumentation & Control Ladder Diagram Typical	<u>No.64</u>	<u>No.64</u>
Instrumentation & Control Wiring Diagram Typical	<u>No.65</u>	<u>No.65</u>
Instrumentation & Control Cabinet Layout Typical	<u>No.66</u>	<u>No.66</u>
Instrumentation & Control Detail & Schedules Typical	<u>No.67</u>	<u>No.67</u>
Instrumentation & Control P & ID – Typical	<u>No.68</u>	<u>No.68</u>
Instrumentation & Control Site Diagram – Typical	<u>No.69</u>	<u>No.69</u>
Stub-out Configuration for Future Main Extensions	<u>No.70</u>	<u>No.70</u>
Stub-out Configuration for Future Main Extensions	<u>No.71</u>	<u>No.71</u>
Valve Operations	<u>No.72</u>	<u>No.72</u>
Outside Settings for 1 1/2" & 2" Irrigation Meter in Vault	<u>No.73</u>	<u>No.73</u>
Turbine Meter	<u>No.74</u>	<u>No.74</u>
Turbine Meter Dimensions	<u>No.75</u>	<u>No.75</u>
Master Meter for Emergency Interconnection Plans & Details	<u>No.76</u>	<u>No.76</u>
Master Meter for Emergency Interconnection Details & Dimensions	<u>No.77</u>	<u>No.77</u>
Above Ground Dual System Interconnection	<u>No.78</u>	<u>No.78</u>
Below Ground Dual System Interconnection	<u>No.79</u>	<u>No.79</u>
Single Feed System Interconnection	<u>No.80</u>	<u>No.80</u>
Standard Design for Hydrant Interconnection	<u>No.81</u>	<u>No.81</u>
Pitot Installation	<u>No.82</u>	<u>No.82</u>
Standard Design for Hydrant Meter Installation	<u>No.83</u>	<u>No.83</u>
Standard Design for Blowoff Hydrant	<u>No.84</u>	<u>No.84</u>
Tracer Wire Installation for PVC Water Main	<u>No.85</u>	<u>No.85</u>

Traffic Impediment Bollard	No.86	No.86
Submerged BFV with Torque Tube and Actuator Stand	No.87	No.87
Recycled Water System Pentagon Operating Nut	No.88	No.88
Specimen Illustration Formats >>	PDF	CAD
■ <i>General Instructions</i>	G. Ins.	G.Ins.
■ <i>Specimen A. DW Standards</i>	4-06A	4-06A
■ <i>Specimen B. Border/Title Block</i>	4-06B	4-06B
■ <i>Specimen C. Perimeter Description</i>	4-06C	4-06C
■ <i>Specimen D. Overhead Crossing</i>	4-06D	4-06D
■ <i>Specimen E. Underground Crossing</i>	4-06E	4-06E
■ <i>Specimen F. Centerline Description</i>	4-06F	4-06F
■ <i>Specimen G. Simplified Area</i>	4-06G	4-06G
■ <i>Specimen H. Fire Hydrant Easement</i>	4-06H	4-06H
Attachment A: Color/Pen Width Chart		Attachment A
Abbreviation List		Abbreviations